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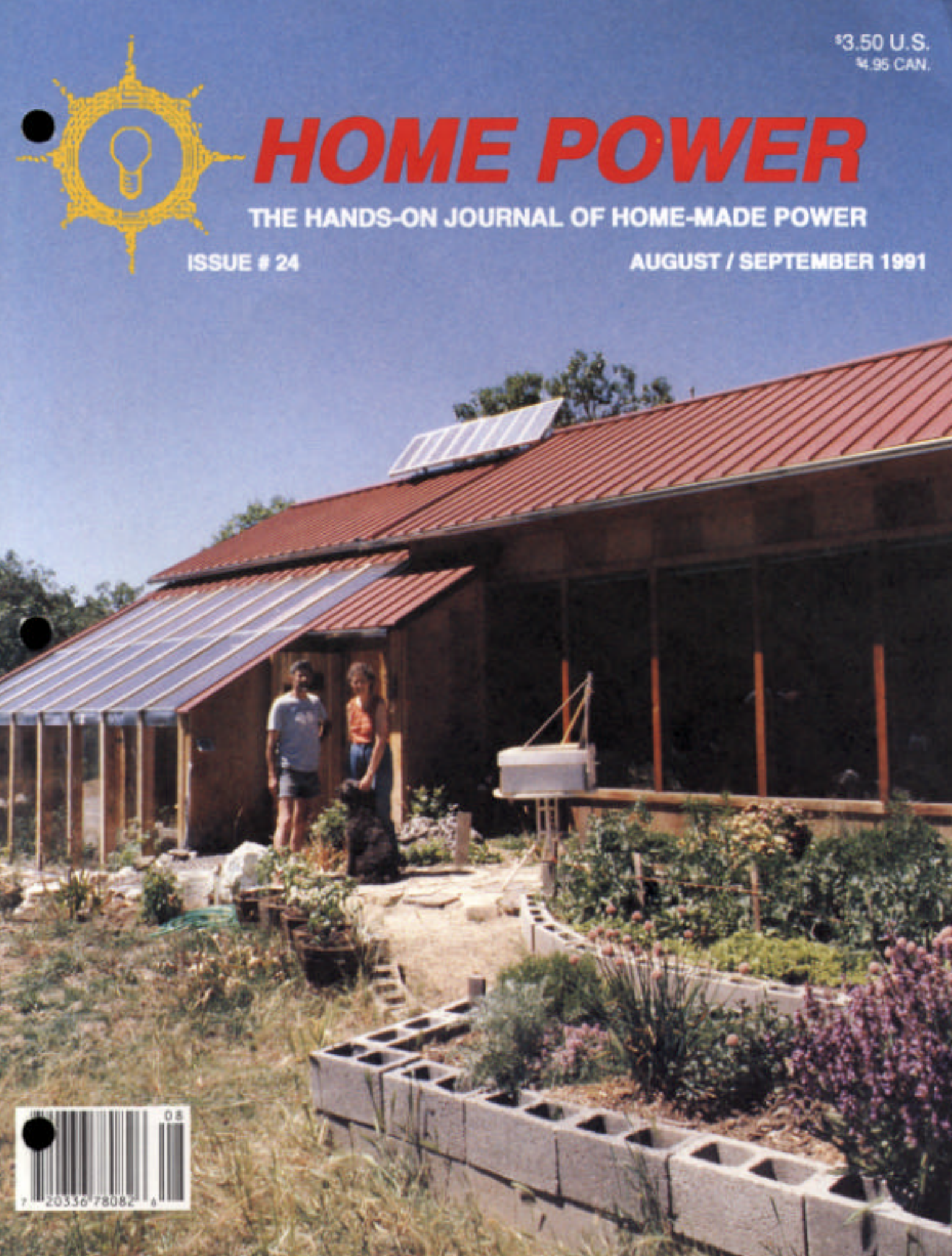
HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

ISSUE # 24

AUGUST / SEPTEMBER 1991



REAL GOODS

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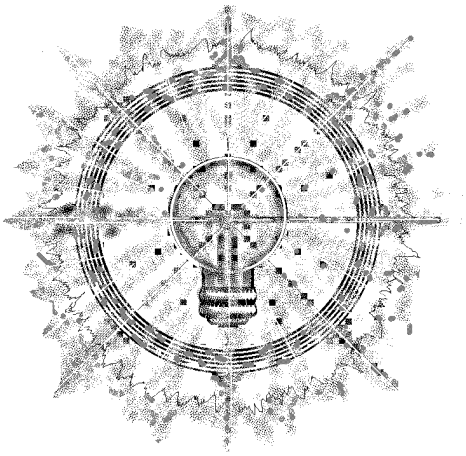

HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

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Access

Home Power Magazine
POB 130
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Think About It

"Anger is useless,
Tenacity moves mountains,
Honesty is magic."

Unknown via Greg Nolan

Cover

Sunshine provides electric power and heat for this Oregon earthbermed home. Story on page 6.

Photo by Richard Perez.

From us to YOU

WORK

Country people know how to work. They dig in and do the job until it's done. This spirit of work is most evident at this year's energy fairs. RE folks have moved heaven and earth to make these fairs celebrations of joy and hope.

After the Midwest Renewable Energy Fair ended, Karen and I talked with the tired but still smiling MREF crew. Dozens of the finest folks gave months and weeks of their lives for a single weekend's event. They worked hard not for money, but for our future. These folks have the *Spark* in their eyes. These folks see a clear and working way to a solar-powered future. I salute their work!

And more fairs to come

SEER '91, Willits, CA on August 9th to 11th 1991. Be there and get *Sparked!*

Can do

It is the "can do" attitude of home power people that gives me hope for our future. Check out the articles in this issue. These are serious, hard-working people who have let the sun into their lives. They are using renewable energy and good 'ole fashioned work to live self-sufficient and sustainable lives. They are already living the future.

Home Power's work is communicating this information to you. We are caretakers of the *Spark*.

Above: Karen and Richard relax after after pasting-up an issue of Home Power. This is a wonderful time for us. Months of work have climaxed in a single afternoon. The issue is done and ready for the printer; and we get to

People

Willson Bloch
Sam Coleman
Todd Cory
Clive Ellis
Wayne Green
Nancy Hazard
Tom Heinrichs
Kathleen Jarschke-Schultze
Pamela Jung
Jack Knowles
Stan Krute
Jim Lambesis
C, Michael Lewis
Dan Lepinski
Alex Mason
Ken Olson
Karen Perez
Richard Perez
Patti Penland Phelps
Mick Sagrillo
Bob–O Schultze
Johnny Weiss
Robert Wills

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TRACE

FULL

PAGE

AD

Above: a view of the south side of Colin and Christine's home. Large south facing windows and a greenhouse heat the home with sunshine. Photovoltaic modules on the roof provide the electric power. The solar oven in front of the house is baking bread. Photo by Richard Perez.

Just say, "Yes" to sunshine

Richard Perez

Living with renewable energies means graciously accepting what Nature offers. Colin McCoy and Christine Reising do just that. Their Oregon mountain home is heated and powered by the Sun. This owner designed & built, earthbermed building uses only energy resources found on site. Colin and Christine have made a home that is warm, sustainable, independent, and inexpensive. They accomplished this for themselves by accepting the plentiful renewable, natural resources that surround them.

Location

Colin and Christine live in the mountains outside of Jacksonville, in southwestern Oregon. At their elevation of 3,000 feet, there is abundant sunshine above the fog that often blankets the nearby lower valleys. Their homestead is located about one mile from the nearest hard surfaced road or commercial electrical hookup.

Colin & Christine's Homestead

In the short period of two years, Colin and Christine built their home themselves. The house is earth bermed on its north and east side. Solar heat warms the home from its large south facing windows and from the a greenhouse attached to the home's southeast corner. Air is circulated through this two–story, 2,000 square foot home by natural convection currents.

Colin and Christine are serious about construction. Colin realized that heavy equipment was the best way to move all the dirt and rock necessary to make his homestead. Colin bought a used small bulldozer and used it to construct the earth berm for the house , to rough out the garden, and to dig two ponds.

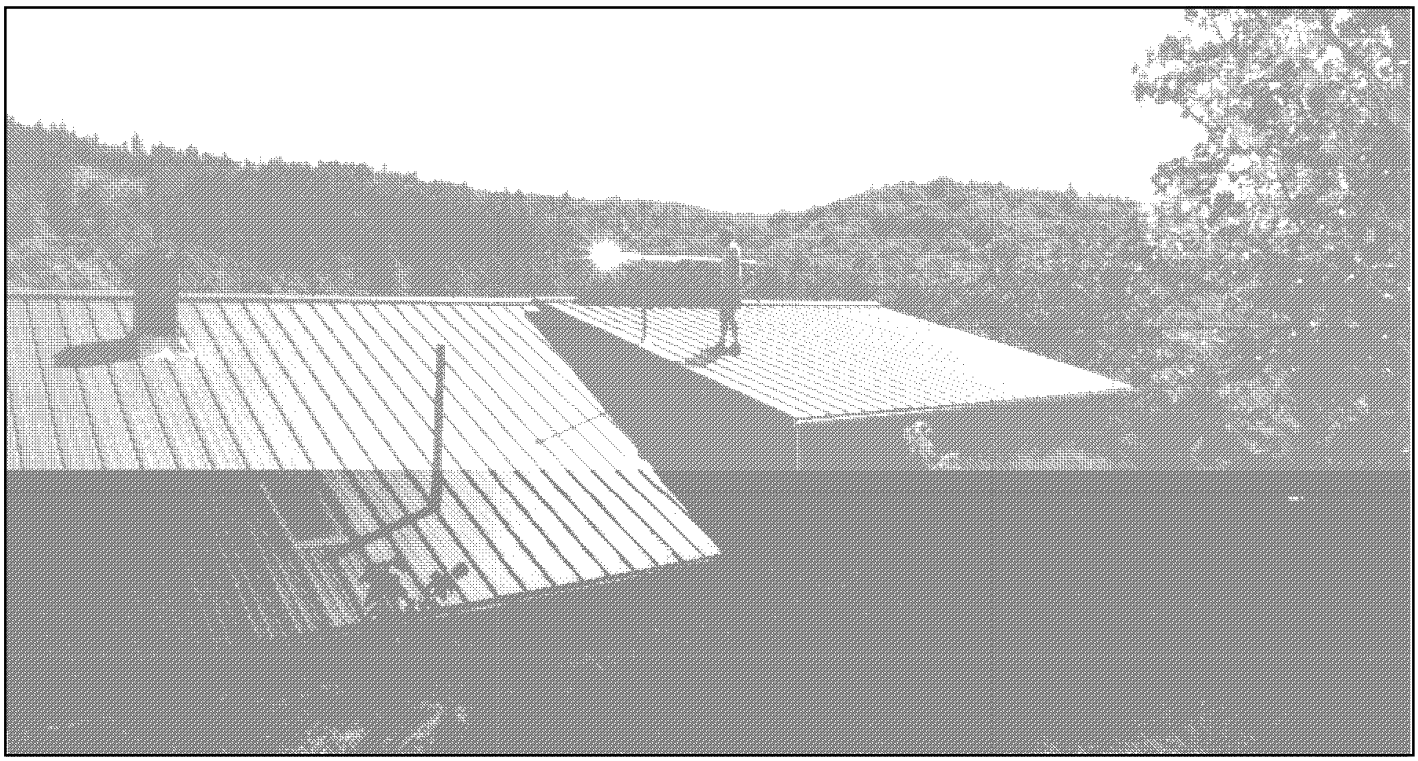
The concrete work that forms the north and east sides of the house was accomplished by dry stacking concrete blocks. Colin mentioned that the dry stack technique did not require constructing wooden forms. The blocks were reinforced with steel rebar and filled with cement. The wooden portions of the walls in the south and west were insulated to R-19 or R-24 with fiberglass. The floor is a six inch concrete slab reinforced under the 2.5 ton masonry chimney and stove in the home's center. The home employs virtually no north facing windows, but instead uses skylights for natural lighting.

The large south facing windows use two panes of glass to reduce heat loss. Colin and Christine bought these factory-made windows direct from Arctic Glass in Minnesota (715-639-3762) and have found that they work well. During the winter nights or summer days, each window can be covered with reflective curtains that roll down to control the home's temperature. During the winter these curtains minimize heat loss from the large windows. During the summer the same curtains shade the home's interior and keep it from getting too warm. The large mass of the tiled concrete floor and the monster masonry stove/chimney act as heat sinks. This thermal mass holds the heat during winter nights and keeps the home cool on hot summer days.

Colin designed the home and it is beautiful inside. This is Colin's third home building project and his experience shows brightly in this home. The design is functional and simple to build. The interior spaces are large and open. The kitchen and the library are the twin focuses of the home's design. This is a home in which it is impossible to feel either alone or gloomy. A riot of color and life flourishes in the gardens just outside the large south facing windows.

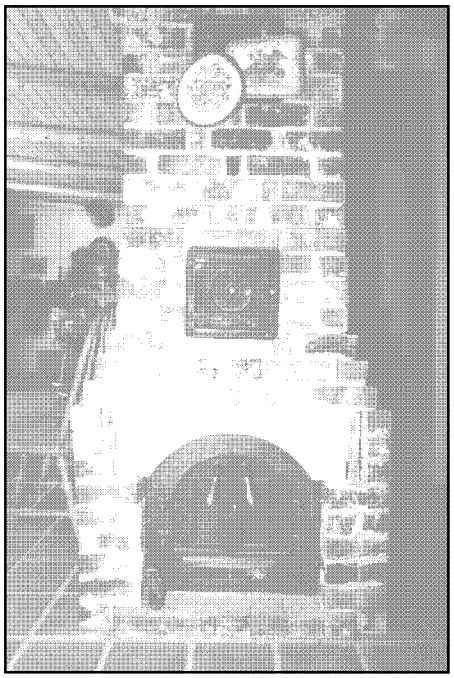
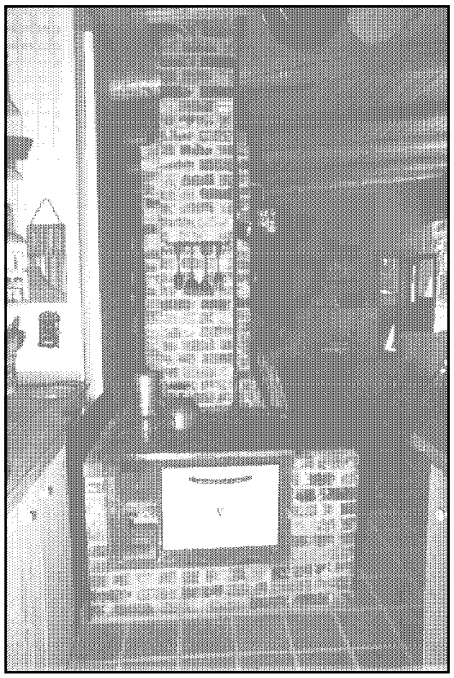
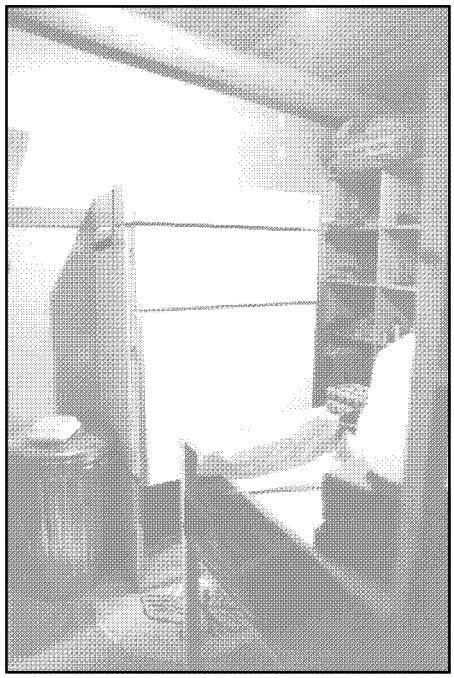
Solar and Wood Heat

If the sun doesn't provide the heat, then wood does. Southwestern Oregon has a mild enough climate that a solar heated home is a working reality. Adding a greenhouse and using its hot air for the home, adds even more heat during the winter. Only during days of continuously cold and stormy weather is the backup wood Russian type mansonry heater used.



Above: the north side of Colin and Christine's home. This side is built into the earth for thermal stability- making the home warm in the winter and cool in the summer. Colin is on the roof checking out the PV array. Photo by Richard Perez.

Above: a view of the kitchen. Note the heavy mansonry stove/chimney. Below: a view of the library. Photos by Richard Perez.

Above Left: Colin built this monster woodstove into the chimney's east end. Above Center: the wood cookstove is built into the chimney's westend. Above Right: with a large garden, the Sun Frost RF-12 stores many home-grown veggies.
Photos by Richard Perez.

Colin and Christine burn about one and one-half cords of wood yearly. They merely clean up the dead hard wood on their property and use it for space heating, cooking food, and heating water.

In the center of the home sits a massive Russian type stove & brick chimney. This chimney has a serpentine smoke path fed by two different wood stoves. One stove is built into the chimney and will consume logs up to four feet long. This large wood heater provides backup heat for extended cloudy and cold times. The second stove built into the chimney is a wood cook stove complete with oven. Colin and Christine do all their indoor cooking on this wood cookstove. They don't use electricity, propane, LP gas, or natural gas for any thermal applications. Their wood cook stove is equipped with a cast iron water jacket. Hot water is thermosyphoned through the wood stove and stored in a conventional hot water tank.

The afternoon that Karen and I arrived to meet Colin and Christine, they were baking bread in a newly constructed solar box cooker. They are actively experimenting with solar cookers because cooking with sunshine fits with the way they live. Colin builds a fire and makes breakfast on the cookstove just about every morning. This short fire cooks breakfast, warms the home, and heats water for the day's use. During the sunny portion of the day, dinner can be made in the solar cooker without warming up the cool house.

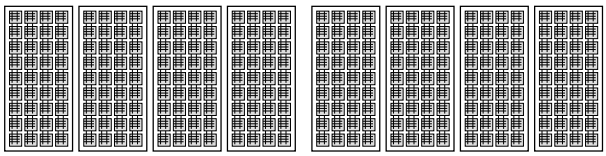
Colin & Christine's Solar Electric System

Appliance use is strictly 12 Volt DC. Colin and Christine use electricity for only essential applications like lighting and refrigeration, and maybe a few luxuries like toast in the morning. Christine loves toast for breakfast and makes it on a 12 Volt toaster each morning. The chart below details the appliances used by Colin and Christine. The major consumer is the 12 Volt powered Sun Frost RF-12. This super efficient 12 cubic foot refrigerator and freezer allows Colin and Christine to keep food fresh for only about 440 Watt-hours of power daily. Their light is provided by three 12 VDC fluorescent lights for long

Colin & Christine's 12 Volt Appliances

Appliance	Watts	On time hrs. / day	Watt-hrs. per day	%
Sun Frost RF-12 Refrigerator/Freezer	55	8	440	56.4%
Lighting (Fluorescent & Incandescent)	60	5	300	38.5%
Toaster	250	0.16	40	5.1%
		Total	780	

A Block Diagram of Colin & Christine's Photovoltaic Power System.

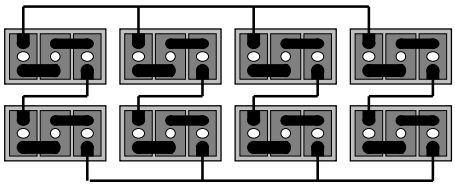


Eight Photovoltaic Modules
360 Watts peak at 12 VDC

Trace
C30A
PV Controller

Alternative
Energy
Engineering
DC
Distribution
Panel

12 VDC
to all
LOADS



Eight Trojan L-16 Lead-acid Batteries
1,400 Ampere-hours at 12 VDC

duration operation, and three incandescent 12 Volt bulbs for short duration use. Both Colin and Christine practice the "One Person, One Light" rule and immediately switch off lights that are unused.

Colin is planning on adding some 120 vac appliances in the future. Christine is an assistant principal at a local high school and could do some work at home with a computer. Colin already has the wiring in for a 120 vac circuit to be supplied by an inverter. This circuit will power an IBM clone computer and printer. Colin is also looking forward to a few motorized appliances like a grain grinder. Colin and Christine use a hand powered Corona grain mill to make flour for their bread. Many times, I have ground fine flour (three passes through the mill) for two loaves of bread on just such a hand mill. This is a very, very good place for a solar powered electric motor. Fortunately, Colin has planned ahead and their system will support these additional appliances with no problems.

The System Hardware

Colin and Christine's PV system is as simple, direct, and effective as everything else in their home. Power is provided by eight photovoltaic (4 Kyocera and 4 ARCO) modules mounted on the roof. There is no backup generator. Photovoltaics supply the only electric power to this home. The photovoltaic array is wired in 12 Volt mode and produces 22 Amperes of peak current. Average power production is around 1,600 Watt-hours daily. A Trace C-30A regulator rides herd on the PVs and protects against battery overcharging and system overvoltage.

Power storage is in eight Trojan L-16 lead–acid batteries wired in for 12 Volt operation. The resulting battery stores 1,400 Ampere-hours at 12 VDC or 17.2 kiloWatt-hours of power. This battery stores enough power to run the home for thirty days of continuously cloudy weather. Cloudy periods this long just don't happen in southwestern Oregon. The batteries, regulator, and distribution panel are located in a garage in the west side of the house. This earth bermed room provides a temperate environment for the lead-acid cells and removes them from the living areas.

Power is distributed by an Alternative Energy Engineering power panel. This low voltage distribution panel provides fused hookups for all the home's 12 VDC circuits. It also contains the battery voltmeter and the battery ammeter. Use of a 12 Volt distribution panel makes the wiring both easy and safe.

Colin & Christine produce about twice as much power as they consume on a daily average. Battery storage is enough to supply twenty days of power with the array totally disconnected entirely. The net result is a stand -alone PV power system that cost about $4,000. The local utility wanted about $28,000 to hook up the grid to Colin & Christine's home. The day Colin and Christine plugged into the sun, they saved $24,000 and

monthly power bills stretching out forever.

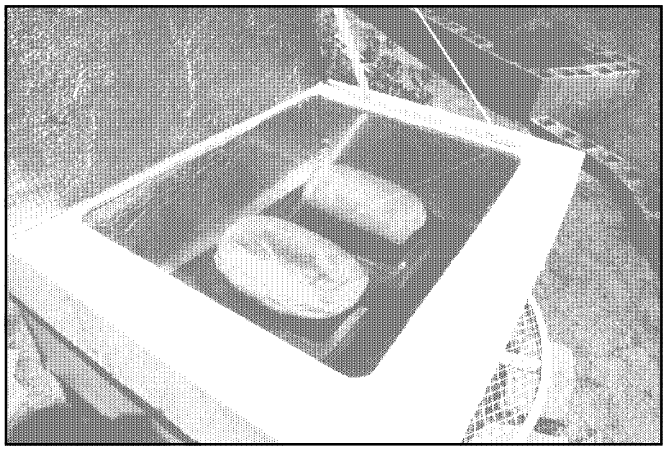
Gardens
Colin and Christine grow large gardens. Inside their amazing world of heirloom plants lives berries, flowers, beans, potatoes, corn, tomatoes, and many other plants. Colin is very active with the local Tilth group. They grow ancient varieties of plants for seed and pass them around so that the strains are not lost. The garden is filled many heirloom strains such as "Howling Mob" corn and fava beans from the Aprovecho Institute. The storage room in the house is jammed with home canned garden produce for use in the winter.

The garden's house is also solar powered with a single SolarWatt 32 Watt PV module, four Trojan T-105 batteries, and a Sun Selector charge controller. This small system provides power for lighting in the garden house.

Water Systems
Colin has constructed three water systems. They all use naturally available water from rain as their source. There are no pumps or electrical power involved in any of the three water systems. Domestic water is supplied by a rain harvesting catcher system located about 400 feet from and 40 feet above the house. A 20 foot by 20 foot metal roof catches rain water and stores it in two 1,500 gallon concrete tanks sealed with ferroseal compound. This rain–catcher system allows Colin to collect the water forty feet above the house. This provides water pressure for the home without using a pump. This system supplies the domestic water for the house, except for the flush toilet/septic system. The toilet is operated from rain water collected by the house's roof.

Colin has constructed, with the aid of his bulldozer, two large ponds on the property. These ponds are located about 20 feet above the garden areas. One pond is used to irrigate the extensive gardens, and the other pond is held strictly in reserve for fire protection. Capacity of both ponds combined is about 300,000 gallons– enough for even the dryest summer. These pond refill themselves by rain and natural water run-off from the land. Colin spoke of his dream to turn one of the ponds into a wildlife area, filled with local plants and berries, for the local animals and birds.

Colin, Christine, and their fuzzy friends
I often judge folks by the critter company they keep. In the case of Colin and Christine, they keep the company of some wonderful furry friends. They share life with a large, friendly sheep dog named Maggie and a minipig named Dandy. Dandy is a Vietnamese Pot Bellied Pig and is definitely part of the family. Dandy is allowed inside the



Above: two loaves of bread baking in a solar box cooker.
Below: Dandy the minipig graciously accepts a few raisins from Christine. Phots by Richard Perez.

house and behaves like a perfect gentleman. He sits and snorts when he asks to be fed his favorite food in all the world– raisins. Christine told of training Dandy to sit before accepting food. It took one evening and Dandy had it mastered by breakfast the next morning. Dandy has a bed inside during the winter and a pen outside during the summer. Colin has constructed a watering bowl where Dandy can activate a lever and get a drink. Dandy also has his own sunken tub outside for dunks during hot days. All in all, Dandy is the most personable pig I have ever had the pleasure to meet.

Homesteading

Colin and Christine have worked out a division of labor used by many homesteading families. One partner works out and the other works in. Christine works out in her professional capacity of school administrator. Colin remains home to do the full-time job of homesteading. By adopting this division of labor they have the dual advantages of some cash income from one partner and many hours of homesteading labor from the other.

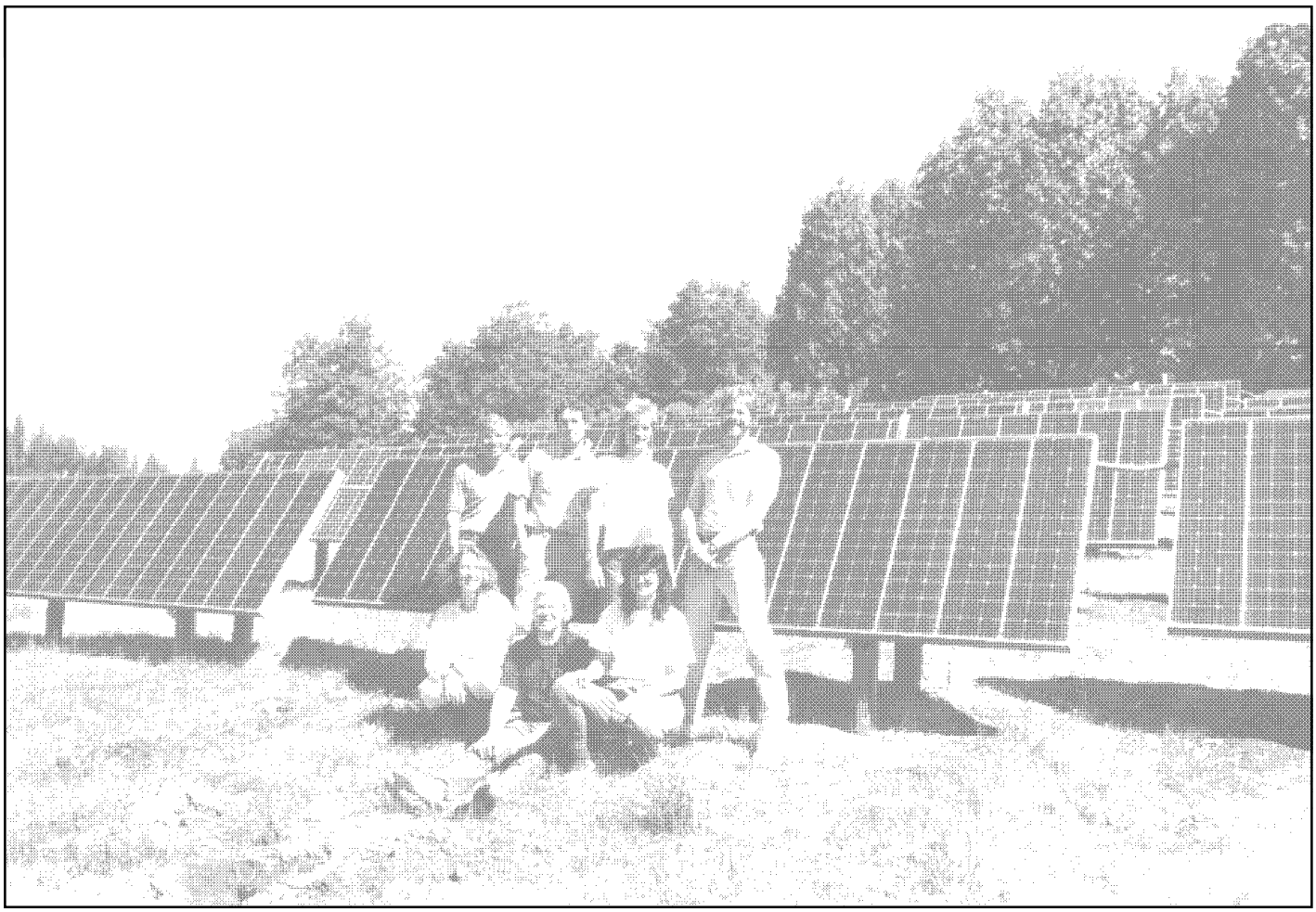
The key to Colin and Christine's success is sensible, appropriate use of what nature has offered them. They have aligned their lives so that each of them can work with their best skills. They have accepted natural and renewable sources for their food, water, shelter, and energy. They have surrounded themselves with a growing community of plants and loving friends.

As I sat eating a slice of their solar cooked bread, I thought to myself how very easy it is to just say "yes" to sunshine.

Access

Author: Richard Perez, C/O Home Power, POB 130 Hornbrook, CA 96044 • 916-475-3179.

Homesteaders: Colin McCoy and Christine Reising, C/O Home Power, POB 130 Hornbrook, CA 96044.



Above: The Ananda Electric crew in front of the system's PV array. Back row, left to right: Jim Agee, Jack Knowles, Jeffrey Philpott, and Rodger Hall. Front row, left to right: Pam Jung, Bob Ramsaur, and Suzanne Betts.

Central Solar System Serves Four Homes

Jack Knowles with Pamela Jung

Five years ago Hunter Black was taking a course in construction management when he happened on the book "Form and Function" by Paul Jacques Grillo. Hunter Black had what he calls "an awakening." "Gone," he said, "was my interest in the standard construction mode that I was being taught. I wanted to discover inspiring, practical, and, above all, natural methods of design and construction. I wanted to build 'real' houses– houses, in other words, that combined a harmony of spirit and nature."

Ananda

About that time Hunter learned about an intentional community that was based on principles of meditation and cooperative living. It was located in the foothills of the Sierra Nevada in California, about 80 miles northwest of Sacramento. He visited the 800-acre community--named Ananda--with his wife and four children. They liked what they saw and decided to move there. Hunter brought along with him a design he had done for a school project for a solar adobe house.

Well, four years later in 1990 the concept of a single adobe house had enlarged a bit. It had turned into a 5,000 square foot rammed earth home that was part of a cluster of four homes--all of them sharing one central solar power system. This system includes a central solar

array of 288 modules and a central power building filled with batteries and power equipment. It is designed to service a total of 9,000 square feet of housing that accommodates eight adults and 7 children.

The cluster took its name of Almora from a sacred spot in India with a long spiritual history.

System Design

Ananda Electric, an electrical contracting company in Nevada City, California, which has a division that specializes in photovoltaic installations, designed most of the system and installed it. Sam Vanderhoof and John Berdner of Photocomm Inc. of Grass Valley, California assisted in the design and provided most of the major components. The home owners in Almora, especially Hunter Black who was the originator of the idea of a central system, assisted by providing the solar array mounting structures, constructing the power building, and installing the underground conduits.

Well before construction started the home owners calculated how much power each home would use. From that information we at Ananda Electric arrived at an average daily power usage. Using a computer program from Photocomm, we were able to come up with figures on the average amount of sun hours available for every month of the year. This is based on the weather patterns in our particular area. From this information we sized the array and the battery banks, allowing for 5-7 days of reserve power in the winter.

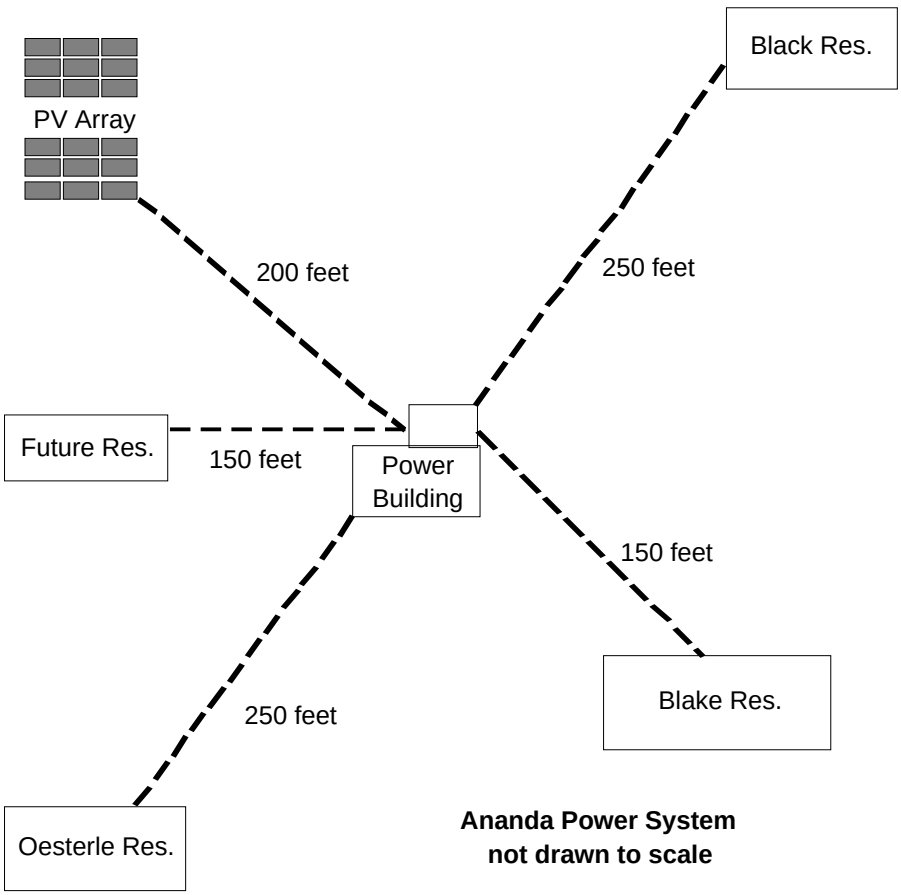
As you see in the diagram, the homes are 100' to 250' from the central power building, and the solar array is 200'--a substantial distance that required large wires that greatly added to the cost. This was done because of personal preference and not because of technical considerations; the home owners simply wanted a certain layout--one that took advantage of configurations of the land, allowed for views, preserved trees, and generally just "felt good," as they put it.

Because the layout was so optional we have separated out the cost of the large wire and conduit feeds from the array and to the houses (in the cost breakdown at the end of this article) so readers can see the cost differences if houses and array were placed closer together. Indeed, if the distances were cut in half, the savings on these wires and feeds would be more than 50% because you could use smaller wire and less of it.

The Array

The solar array is made up of M-51 style 4-volt laminates (which are commonly used to make what is known as "Tri-Lams" or "Quad-Lams"). These came from an ARCO power plant with 16 laminates, or modules, mounted into one solid metal frame with copper bussing tying them together. This configuration of these huge units, which we nicknamed "Monster Modules", made them very easy to mount as we only needed to support and bolt down the main frame. Each "Monster Module" is supported by four pressure treated 8" poles set in concrete. We bolted two pieces of slotted galvanized angle iron to the poles, then bolted the modules to the angle iron. By doing some minor rewiring we got the 24-volt output we needed. We drove a 5/8" x 8' ground rod for each set of three "Monster Modules", making a total of six ground rods at the array.

The number of laminates/modules presently installed is 240, and these adequately serve the needs of homes totaling 8,000 square feet. Another 48 will be added when



Ananda Power System not drawn to scale

the 4th house of 1,000 square feet is built by a couple with a baby.

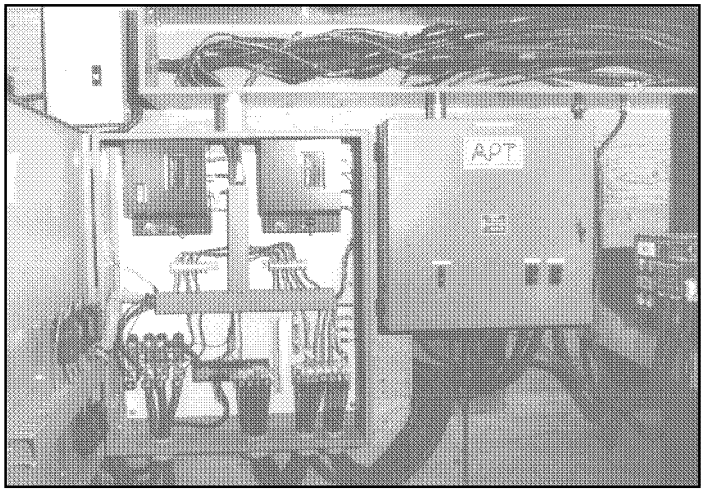
The system is designed to give a total continuous output of 6,600 watts with about 40,000 watt-hours generated in the winter and 60,000 in the summer. That is total daily output on an average clear day.

The Power Control Panels
At the heart of the system are the power control panels. Ananda Power Technologies (APT, Inc.) custom manufactures these in their shop. They are the same company that makes the "Ultra Power Center" that is marketed by Photocomm. Inc.

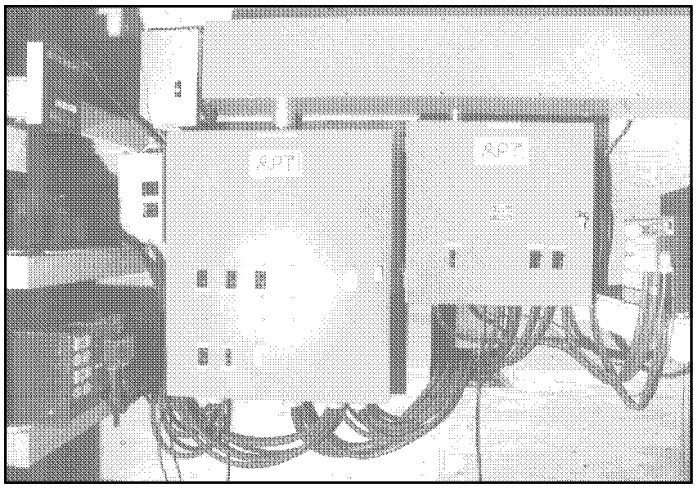
One enclosure is 24 inches x 24 inches and the other is 36 inches x 30 inches. Housed inside are three Heliotrope CC120B charge controllers, two 800 amp shunts for the Cruising Equipment Co. ampere–hour meters, three double shunts for the SPM 2000 meters, and an assortment of lugs, fusing, bussing and wires. A generous amount of ventilation and additional heat sinking is built in to dissipate the very high heat given off by the FETs in the charge controllers. Mounted in the front doors are 60 Ampere 2 pole Square D breakers. These provide overcurrent protection and disconnecting means for the incoming array and outgoing DC lighting and small appliance loads. The array breakers interrupt the power before and after the charge controllers so that they are completely isolated from the system for ease of maintenance and proper protection.

We drove one 5/8 inches in diameter x 8 foot ground rod at the control panel. This rod is bonded to the negative termination lugs for the battery, array, and load wires with a #2 copper conductor. We bonded a #6 wire to the metal housings of the inverters, control panels, and the 5 foot x 10 inch x 10 inch raceway.

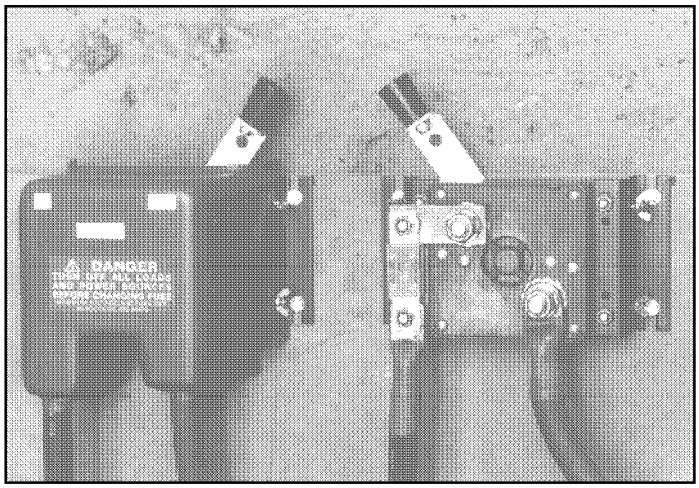
The Power Building
This building consists of a 10 foot x 15 foot rammed earth walled section for the battery room and a shed type portion with a cabinet to enclose the control panels, inverters, and battery charger. Rammed earth construction is a great way to go because it provides stable temperatures for the batteries. A small Kohler 3 kw low rpm generator and a IBE 60 Ampere, 24 Volt battery



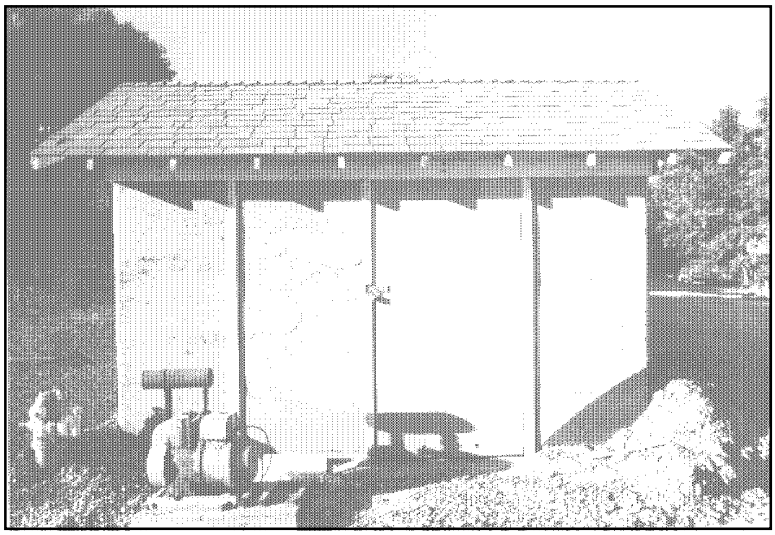
Above: One control door open and wireway cover removed. The large #4/0 - #400MCM wires from the array and homes come into the wireway and are reduced to #6 for termination in the power control panels.



Above: the equipment cabinet inside the power house. Inverters are on shelves on either side of the power control panels. Cables pass through the square hole in the wall and to the batteries on the other side of the wall.



Above: A close-up of the 400 Ampere battery disconnect switches, one with its cover removed. These switches are fused. Note that all battery cables are crimped, soldered and insulated with heat-shrink tubing.



Above: the rammed-earth battery/power building.

charger provide the backup charging. With the size of the solar array, we predict the generator will seldom, if ever, be needed, but it's nice added insurance.

The Batteries

We wired six Trojan 175J15, 1493 Ampere-hour, 24 Volt steel cased batteries in parallel for a total storage capacity of 8,958 Ampere-hours or 215,000 Watt-hours. Each battery has a 400 Ampere fused 1 pole disconnect switch for protection and ease of maintenance. These switches are another product made by APT, Inc. A separate run of 4/0 welding cable attaches each battery to the disconnect switch, and from the switch on to the lugs in the control panels.

These batteries are heavy, very heavy. They weigh in at 2,500 pounds each. We used a forklift to get them to the building. Then with lots of sweat and muscle, we rolled them over 2 foot sections of 2 inch pipe and pry barred them into position.

By the way, we prefer these batteries that are composed of factory installed cells and cell interconnects as opposed to batteries that require you to install the loose cells. Even though it might be easier to move the components around in the latter, the factory installed versions greatly reduce any chance of battery terminal corrosion.

The Inverters

Each home has its own inverter which consists of: one Photocomm 4,800 watt continuous 120/240 volt ULtra Inverter, one Photocomm 3600 watt continuous 120/240 volt ULtra Inverter, and two Trace 2524s for the homes with lower power needs. All inverters have performed flawlessly. The only unpleasant incident happened when a carpenter plugged his Bosch cordless battery charger into a Trace 2524 and the charger melted down, case and all. Makita chargers seem to work fine. Just be careful and check to see if your charger gets very hot right away. If so, you'd better unplug it immediately because it's telling you it can't run on an inverter.

Meters and Controls

We installed at each house a SPM 2000 that gives a digital readout of battery voltage, array and each house's load current and keeps a running total in watt-hours and amp-hours for array input and load draw. We also installed a Cruising Equipment Company Ampere-hour meter to monitor how full the batteries are. This meter monitors the actual Amperes in and out of the battery with compensation for inherent losses. A regular Volt meter, on the other hand, can only give you valid readings on the amount of charge when the batteries are in state-of-rest condition with no charging or discharging occurring. See Home Power #16, page 40 for a review of the Cruising Equipment Ampere-hour meter.

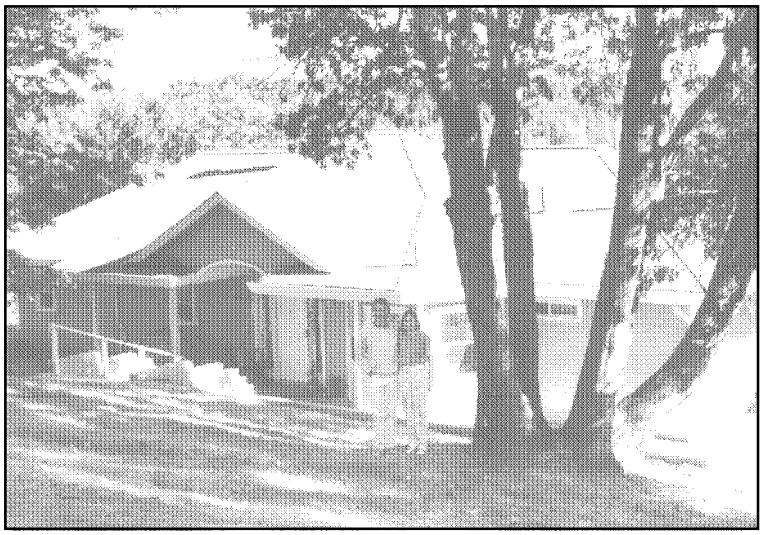
A handy control feature of the Photocomm inverter is its remote switch (which we installed in the houses) to control "Always on", "Off", or "Sleep" mode. This allows you to keep a low wattage draw device such as a VCR operating to record a show while you are gone. Or by shutting the inverter down as you leave you can be sure no power is used by something you may have forgotten to turn off.

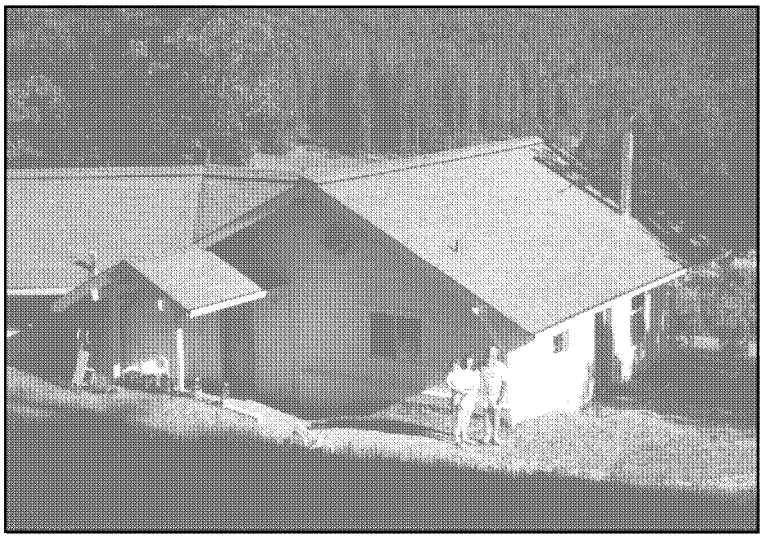
The House Wiring Systems

The houses have a combination of AC and DC wiring in them. Most of the lighting is 24 Volt DC with a mixture of incandescent, quartz, compact fluorescent, and large fluorescent lamps. The homes have wiring for DC refrigerators with Sun Frost units installed in two of them and propane in the other two.

The 120 volt AC is used for table and floor lamps that plug in and a few hard wired fixtures, compact fluorescent lamps are used in these. The AC power also runs the clothes washer, dryer, small kitchen appliances, coolers, vacuum cleaner, entertainment equipment and miscellaneous items.

We installed three conductor stranded #12, #10, and #8 gauge Romex for the 24-volt DC, and we ran some #2/0 feeders in the 5,000 square foot home due to the long runs and voltage drop problems. We used the three conductor cable so that one wire could be a ground for the fixtures. Thus, we not only met the National Electrical Code standards that say any metal parts of fixtures or





electrical equipment need to be grounded, we also made it possible for the entire house to be switched over to 120-volt AC in the future if it should ever be needed.

An important ingredient in the DC lighting system is the use of DC rated switches. We use Leviton #1330-I for the single pole and #1331-I for the three ways. These may need to be specially ordered from your local electrical supply house.

Square D size 12/24 load centers with QO style breakers were used to distribute the 24-volt load because they have a DC rating and high reliability.

We did the AC wiring with normal romex in the standard fashion. The 120/240-volt AC power is distributed with ITE/Siemens standard residential load centers and breakers.

Conduits and Wires

At each home we installed a 3-inch conduit for the DC, a 2-inch conduit for the AC and a 1-inch conduit for the metering and control wires. For the DC house loads the wires range in size from 4/0 up to 500 MCM aluminum, depending on the amount of load and the distance. The runs are from 150' to 250' long, which requires large wire sizes. The AC feed wires ranged from #2 on up to 2/0 in size.

Because the average run to the array was 200' we installed a 2" conduit with two 400 MCM aluminum wires on each set of 48 modules. We used splicer/reducers on each end of the array and DC load wires to reduce the size down to a #6 copper THHN at the control panels and a #2 copper XLP at the array. This helped us manage and terminate them easily. For the metering and control wires we installed fifteen #14 THHN stranded wires, color coded the same as the wires on the meters.

We used aluminum wires for the large main feeds because the cost was one half of copper in the same amp carrying capacity. Aluminum wires must

Three of the Families served by the Central Solar System at Ananda.

Top: Tom and Mary Oesterle at their new home.

Center: Eileen and Haridas Blake with their daughter, Rosie, at their home.

Bottom: Audie and Hunter Black with their five daughters in front of their 5,000 square foot rammed-earth home.

be terminated properly to keep resistance to a minimum. Heavy-duty compression or set-screws type lugs must be used with aluminum anti-oxidant compound applied to the thoroughly cleaned cable end.

We sized wires carefully to keep voltage drop to a maximum of 5% throughout the system. We use a computer software program called "Basic Voltage Drop Calculations" (Orloff Computer Services, Santa Ana, California) to make this task easy and accurate.

At the power building we brought all of the incoming array and outgoing AC and DC load wires into a large 10 inch x 10 inch x 5 foot metal raceway (that is nippled to both power control panels). Then we installed the splicer/reducers on the wires inside this raceway, with the smaller wires continuing down into the control panels. We used a special wire pulling winch to pull the large wires through the 200 feet+ long conduits. It would have been extremely difficult, maybe impossible, to do by hand.

Power Consumption

As it worked out in the Almora cluster, two of the home owners did not have the money to both build their homes and finance a quarter of the cost of the solar power system, while the other two did. So they all struck a deal. The two home owners with the extra resources financed the system up front. The others buy their power from them. All the houses have a DC watt-hour meter on them to calculate the amount of power they've consumed in a month. This may well be a perfect solution for any group that wants to be together but has unequal money resources.

These meters will also be giving us useful information for future design purposes. It will be most interesting to anyone interested in cluster living to see how the different numbers of people, square footage variation, and lifestyle habits affect the actual amount of power consumed. It will probably be of great interest to the individual families to see if the power they end up consuming over time matches the estimate they had in the beginning--a reality check that might help reestablish priorities.

The homes are basically very conventional as far as appliances and usage go. Washing machines and gas dryers, small kitchen appliances, entertainment equipment and a normal dispersion of light fixtures. Some homes even have dishwashers and air-conditioning.

The only variations in these homes as opposed to a typical utility connected home are for the refrigerator (they used Sunfrosts and propane), energy efficient lamps and the absence of electric space heating.

Even though it's a little early to get some realistic average usage readings we thought to tell you what we know now. Tom Oesterle, one of the homeowners, reports that they are using about 200 amps, or 4800 watts a day in their home. This is during the early summer months. He admits that he isn't making any effort to conserve power since they have quite a bit more than they need at this time of year. They run their clothes washer and dryer, dishwasher, small appliances and lots of lighting regularly. They also have a few phantom loads that they just leave on all of the time.

Why Build Such a System Together

The reasons for building this type of group configuration, at least for the residents in Almora, are numerous. Contrary to what one might think, the primary reason was not cost savings. In fact, it might even be a wash between the cost of bringing standard utility electric power in and the cost of designing, installing, and maintaining this system; only time will tell on this issue. Nope, the residents' motivation was more complex.

On the down-to-earth level they wanted to achieve the self-sufficiency of a mini-village, shared maintenance, and the efficient use of a renewable resource. On another level they wanted to experience a level of interaction among the residents that went beyond the casual

System Costs for Four Homes

System Equipment	Cost	%
PV Array – ARCO M51 Modules – 288@	$26,460	32.2%
Batteries – Trojan 175J15 (8958 A-h @ 24 VDC)	$22,200	27.0%
Conduit and Wiring – for main-feed to homes	$8,250	10.1%
Inverters – 4@	$7,988	9.7%
Labor – installation of all equipment and wiring	$6,965	8.5%
Control Panels – 2@	$3,580	4.4%
Instrumentation	$2,444	3.0%
Battery Disconnects – 6@	$1,260	1.5%
PV Array Mounting Structures	$1,120	1.4%
Heliotrope CC120B Charge Controllers – 3@	$975	1.2%
Misc. hardware & parts	$450	0.5%
#4/0 Battery Cable	$380	0.5%
Total	$82,072	

neighborliness that is common today and, all too often, unsatisfying. And yet on another level there was even a spiritual aspect to it, a strong desire to live in harmony with nature. As Hunter Black put it, "I think it was more from a spiritual yearning to reflect the divine than a practical understanding of what we were getting into that led to the creation of this solar system. There was, and still is, a lot of risk in creating a system like this. We don't know how much mechanical trouble we will have. There aren't any statistics we can use regarding this. We don't even know how much power we truly need to keep people happy...(but) living in closer harmony with nature should be a goal of all living environments. A closer connection to nature is a closer connection to spirit which is a closer connection to the divine and a whole other world and way of being."

Access

Author/Installer: Jack Knowles, 14618 Tyler Foote Road, Nevada City, CA 95959 • 916-292-3834.

Power Control Panels & Battery Disconnects: Ananda Power Technologies, Inc., 14618 Tyler Foote Road #143, Nevada City, CA 95959 • 916-292-3834.

Component Supplier: Photocomm, Inc,, 930 Idaho-Maryland Road, Grass Valley, CA 95945 • 800-544-6466.

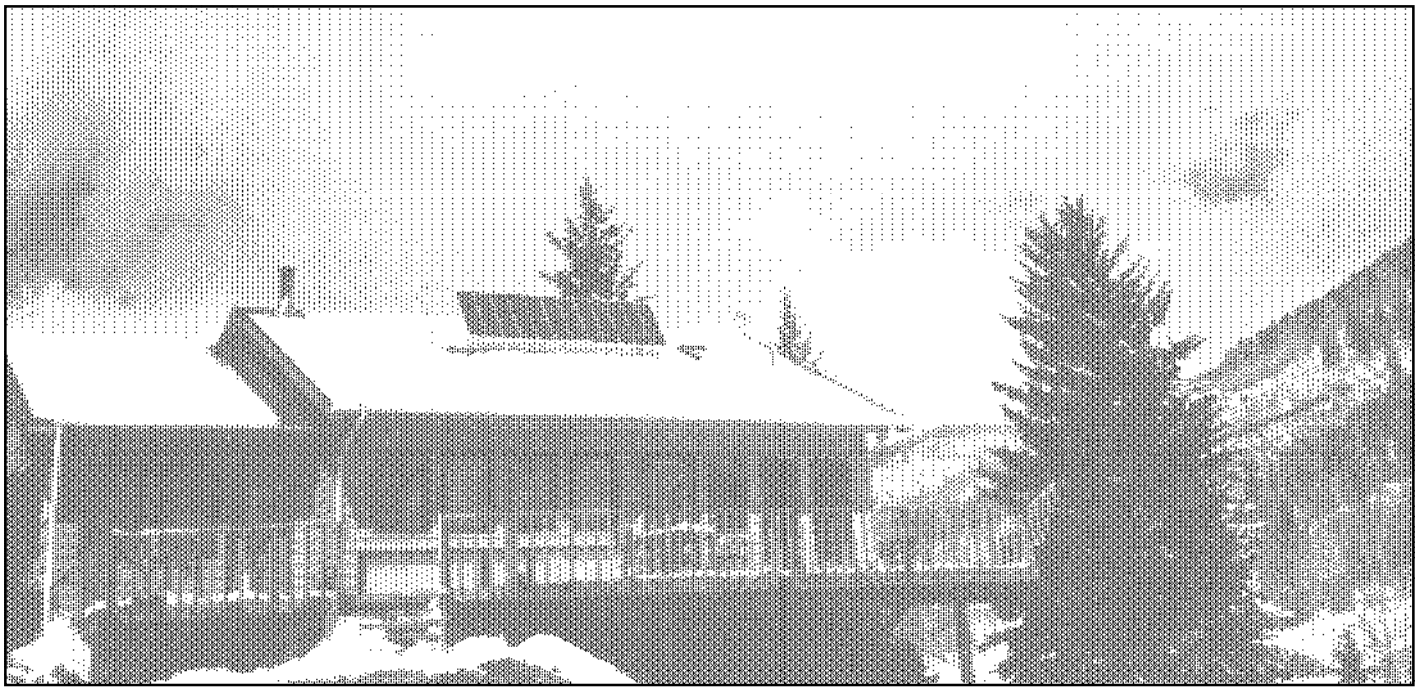
Component Supplier: Trace Engineering, Inc., 5917 – 195th N.E., Arlington, WA 98223 • 206-435-2229.

Component Supplier: Square D, ITE & Leviton. Contact your nearest distributor under "Electrical Supplies, Wholesale" in the yellow pages of your local phone book.

Voltage Drop Program: "Basic Voltage Drop Calculations" – Orloff Computer Services, 1820 East Gary Avenue, Suite 117, Santa Ana, CA 92705 • 714-261-5491.

Rammed Earth Construction: Hunter Black, Healing Earth, C/O Ananda Builder's Guild, 14610 Tyler Foote Rd., Box 117, Nevada City, CA 95959 • 916-292-3292

Photos in this article by Wayne Green.



Above: The Phelps' solar-powered home in the Western Colorado Rockies.

Not Much Different

Patti Penland Phelps

"Hi, I'm so glad to see you! Come in and have a cup of coffee."

This rather routine greeting may not sound significant, but to me it means a lot. It means that I can fix a cup of coffee in my favorite Oster drip coffee pot and can enjoy my friend's visit. Making coffee with an electric coffee maker is monumental because all our electricity comes from the sun. We use photovoltaics to provide power to batteries that give us electricity to operate our household.

In the Beginning

Two years ago my husband, Frank, and I made the decision to build on rural property we own in the Western Colorado mountains. Frank was planning to retire from the FBI and we were finally going to see a dream come true. The first shock came when we found that to bring public service electricity the three miles to our land it would cost $60,000. Both of us have been interested in alternative energy but we had thought of it as supplemental. Now we knew that it had to be our primary source of power.

We began researching everything possible about alternative energy. A small creek runs across our land so we looked at hydro power. Winds gust in this area so we looked into windmills. Western Colorado has almost 300 days of sunshine so we looked into solar power. Finding information that we could understand was a nightmare. When the energy tax credits ended, in 1985, many of the companies producing alternative energy systems closed. Most books and magazines dealing with the subject had been written in the 70s and had become outdated and lacked information on the newest technology. Then a friend suggested that we contact the Solar Technology Institute (formerly Colorado Mountain College Solar Program). This resulted in an upturn in our fortunes. We found that this solar program, run by Johnny Weiss and Ken Olson, was a leader in the United States in solar technology. They had a class beginning in the fall and would consider our home for a class project.

Schools in

In September Frank and I were invited to the class to discuss our plans and needs. We took our floor plan and talked with the 15 students about our dream. The students included 18 year old youths fresh from high school and older adults eager to learn new skills to improve their careers. One woman was a building inspector from New York and another student was from South America. They shared an enthusiasm for using alternative energy and an idealism which was contagious.

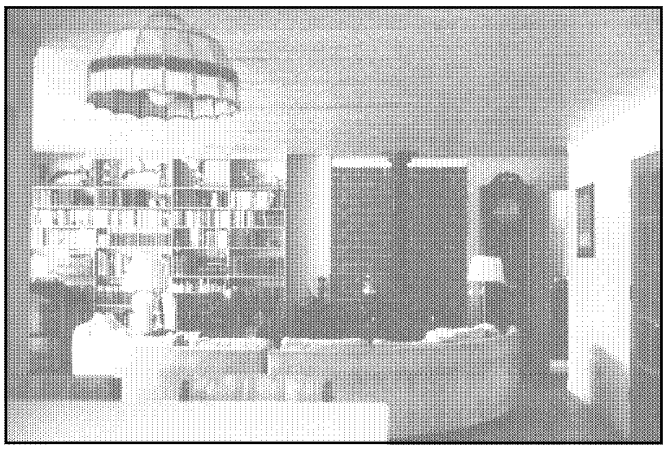
The first thing they did was to question us about our utility use in our normal, city life style. We gave detailed lists including little items like the curling irons up through the coffee pot. These idealistic students then took our lifestyle and began to compute our use of electricity. If you have never done this, it is an exercise that makes you aware, in a very personal way, of how much of the earth's resources you are using and, what is more important, how much you are wasting. The students took each appliance and discussed the watts, amps, volts, and phantom loads. This was where they began to lose me but the most important thing I learned was that heat using appliances like hair dryers, and coffee makers use a ton of electricity.

Costs

The students met with us a few weeks later and they recommended a large solar system which would have cost about $15,000. Frank and I took the list and pared down some of the appliances that we really didn't need. Working with the class and within our budget, we decided on a PV system incorporating 12 panels and 8 batteries with a total of 700 amp-hours at 24 volts. We would have enough electricity for four days and if the batteries needed charging we could use a generator as a backup. I was told by everyone repeatedly that this was a small system and I would have to practice "load management". I had visions of carrying a flashlight in my pocket in the event that I turned on the one electric appliance that would overload the system and everything would go out.

Installation

Purchasing our system was made a great deal easier because one of the largest solar companies, Photocomm, has an office in Denver. The system arrived in the spring of 1990 and Johnny Weiss brought the students up to install the system. We wired the house with a dual system; 110 vac outlets for regular electric uses and 24 Volt DC for a few special uses such as the refrigerator, water pumps and a couple of lamps. The only visible signs of the two systems are the solar panels on the roof, the two breaker panel boxes side by side and several



Top: Frank & Patti Phelps with Juan Livingstone (center) and Davis Chapell (center left). Juan and Davis are STI Solar Program graduates.
Center and Bottom: the Phelps' living room and kitchen.

funny looking outlets.

Graduation
Within two days Johnny Weiss, and his crew of students had electricity in our house. We built the house ourselves and it was an exciting moment to turn on a light and the stereo. Now we have lived with solar power for almost a year and I can say it's the best thing we've done. People often ask me what it's like to live with solar power. I find that I never leave a light on when I leave a room, but I don't hesitate to turn on as many lights as I need when I'm in a room. We bought two new low voltage bulbs from Rising Sun (a light company that specializes in alternative lighting with incandescent lights). These lights give the same amount of light in the same warm tones that the grocery store bulbs give but use just a fraction of the amount of electricity. I still use my sewing machine, word processor, hair dryer, vacuum cleaner, and Cuisinart food processor. I use the 1000 watt microwave with more forethought than I did in town. I play the stereo all day and much of the evening. We watch TV and movies on the VCR. I can honestly say that our lifestyles have not changed because of solar other than that we think about our power use and don't waste electricity.

Changes
We did make three changes that city households wouldn't have to make. We installed a gas clothes dryer, the washing machine is electric and on sunny days I may run as many as 5 loads of wash. We also purchased a new superinsulated 24 Volt refrigerator that runs on much less electricity than a conventional refrigerator. I cook on a gas stove that uses a gas pilot light rather than electric coils.

This winter we learned that the short cloudy days of December and January were the only times we used the generator for backup power; a total of 20 hours for the two months.

Conclusion
We moved to the country a year ago and I must confess that I was concerned about leaving city power and living off the grid. It has not changed our lives and now when friends visit I can relax and enjoy a cup of coffee with them.

Things like volts, amps, and watts still confuse me but I've learned that you can live with solar energy without understanding physics. We are fortunate to have Johnny Weiss and Ken Olson as experts nearby. Johnny and Ken's school, the Solar Technology Institute is a private non-profit school. They will continue to be a leader in the field and a resource for all of us who live off the grid.

Access
Patti Penland Phelps, 13117 Cty. Rd. 245, New Castle, CO, 81647.

KYOCERA PV MODULES

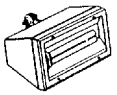
51 Watt – $315 each

12 year warranty

HOXAN PV MODULES Model 4810, 48-50 watt, 3 amp, only **$299 each** in box of 4. A Trace C-30A Charge Controller ($99 value) is included **FREE** with the purchase of each box of 4 HOXAN modules.

COMPACT FLUORESCENT LAMP 15 watt, 120 VAC with replacement PL 13 bulb. These can save about $35 to $65 in electric bills. ($18 value) **$11**

ENERGY SAVING FLOODLIGHT FIXTURE 15 watt, 120 VAC, includes PL13 bulb, polished reflector, weather resistant, for indoors or outdoors **$29.50**



GRAIN MILLS Stone & Burr Mills (60 rpm), AC powered, Hand powered and DC motor driveable

INVERTER BEST BUYS:
24 volt, 2500 watt **TRACE**

TRACE ENGINEERING PowerStar™

INVERTER 2524 with cooling fan option for increased power. Used for less than one year, with warranty. (New $1470) **$945** Save over $500.

DC MOTORS Permanent Magnet, 12v 1/4HP @ 1200 rpm, 24v 1/2 HP @ 2400 rpm, 36v 3/4HP @ 3600 rpm. Great for conversions, fans, pumps, tools, lawn mowers, small electric vehicles. **$125**

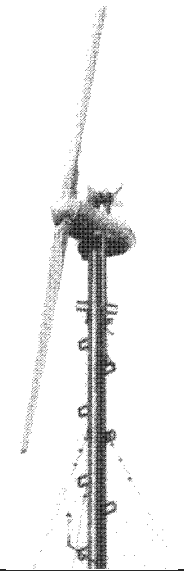
12, 24, 32 volt WATER HEATING ELEMENTS 15 amp.

METER PACKAGE 9-15 voltmeter, 0-15 ammeter, 14 amp circuit breaker, mounted on 4"x7" black aluminum plate for surface mounting. ($99 list price) **$45**

CRUISING AMP HOUR METER with 300% shunt. ($257 value) only **$189**.

SUN FROST 12 CU. FT. REFRIGERATOR The most efficient that we know of. ($1700 value) **$1572**

PROPANE REFRIGERATORS New! 9.5 cu. ft. Servel **$1380** and Servel or Dometic 8 cu. ft. **$1050**



WIND GENERATORS New Models, Used Ones, Parts & Towers. New 5000 watt WhirlWind Wind Generator, 16.4' Blade, ($4600 value) **$4195**

Shipping costs are not included. Shipping rates and many more items are listed in catalog. Prices

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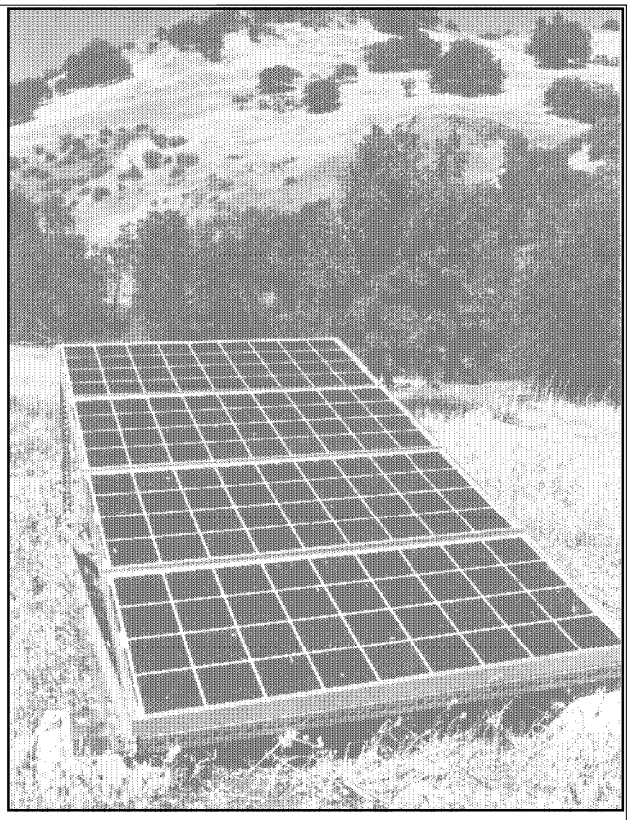
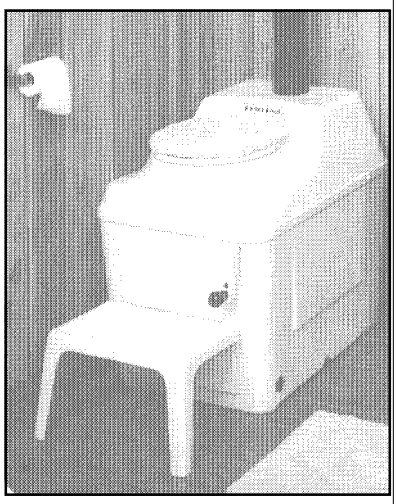
CATALOG $3



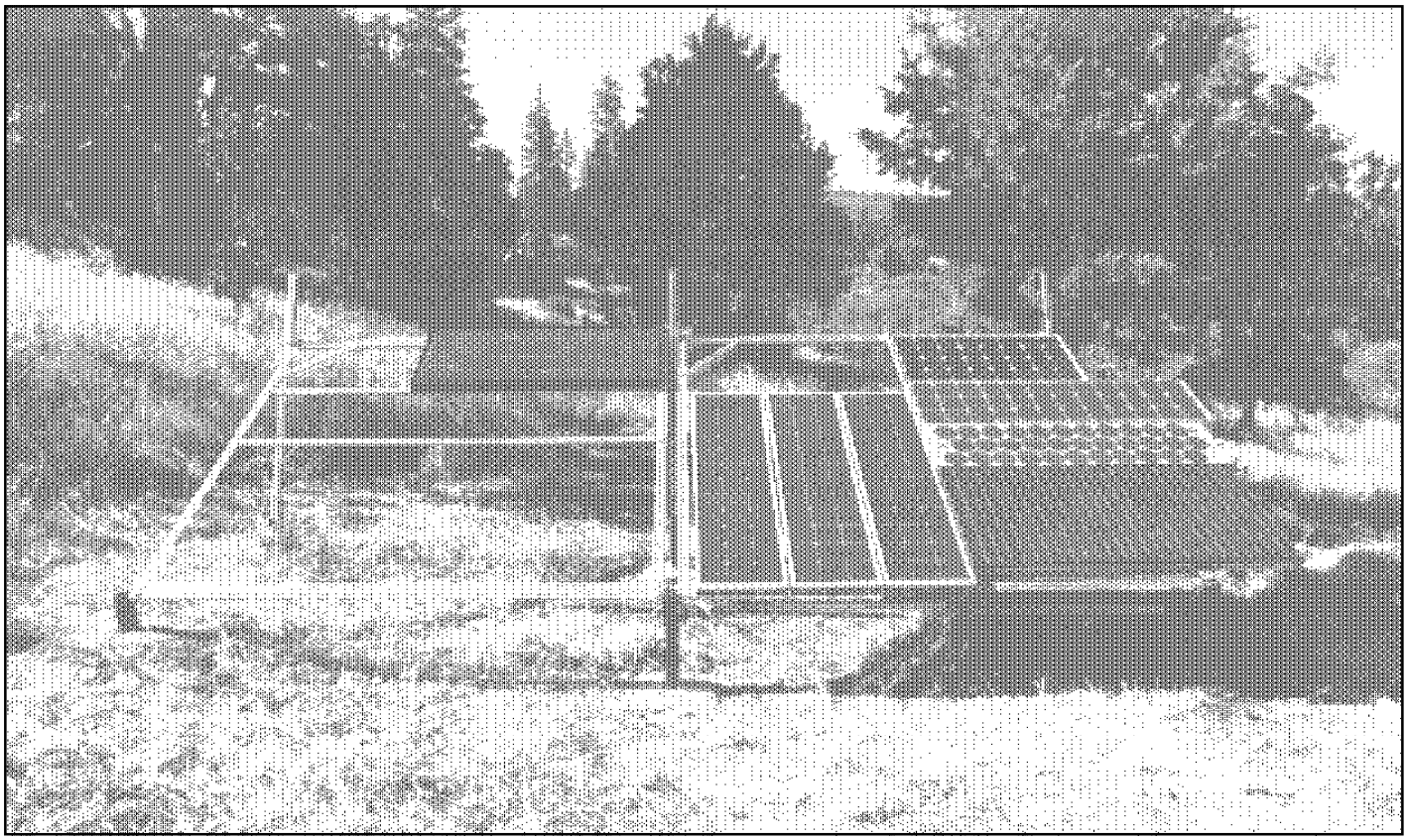
SUMMER SPECIAL PACKAGE:
4 KYOCERA PV modules (204 watts)
TRACE C-30A charge controller 12/24 volt
AMPLE POWER Monitor 12/24 Volt, Amps & AmpHrs
TRACE 612 Inverter.
All this for only $1995! Save about $400.
Some substitutions are okay such as different inverter etc.

NON-ELECTRIC COMPOSTING TOILET by SunMar ($1099 value) **$895**. A 12 volt, 2 watt vent fan option is $46. This is a very good price for one of the finest composting toilets available for the home or cabin.



MINI FLUSH TOILET WATER SAVER KIT Converts a standard 4-6 gallon toilet to a 1.6 gallon flush toilet. ($20 value) **$15**

14 HP ELECTRIC GARDEN TRACTORS 36 volt. No gasoline fill-ups. Use solar & wind energy for recharging. Great for mowing (2-3 acres per charge), towing a trailer, snow removal, plowing rototilling, welding, running power tools (either DC tools or use inverter for AC tools), emergency power source, transportation.



Above: the PV test rack, with some of the modules in place. Bob–O Schultze of Electron Connection gets credit for the ultrafine design and metal work on this adjustable six foot by twelve foot rack. When we did the actual testing at noon, the entire rack was covered with panels. Photo by Richard Perez

Home Power measures PV Performance

Richard Perez and Bob–O Schultze

Ever wonder exactly how much power a PV module makes? We have. We placed just about every make module widely available on the same rack, out in the sun. Then we measured their electrical output, temperature, and solar insolation. Here is what we found.

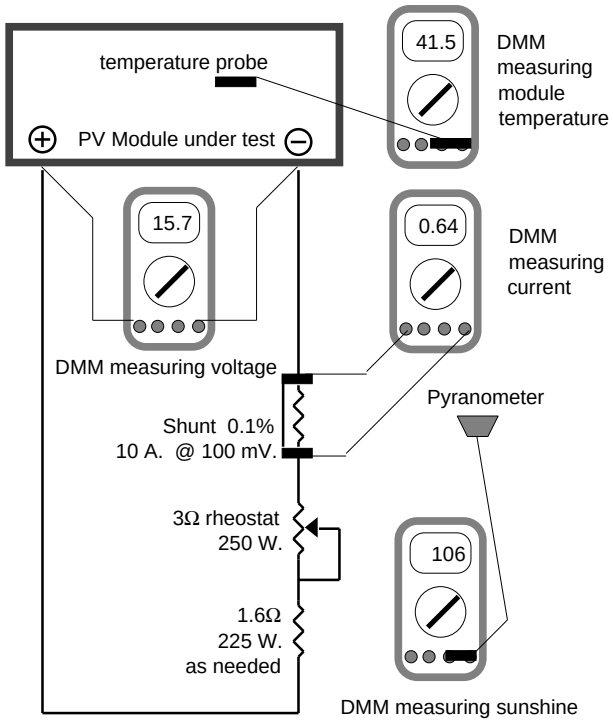
The Test Jig & Procedure

See Home Power #23, page 20 for a complete rundown of our PV module test jig and procedure. Here's what we do in a nutshell. We wire the module into the jig using the instruments shown on the next page.

This test jig allows us to take actual data from each module. With four Fluke 87 DMMs we measure the following data: module voltage, module current, module temperature, air temperature, and solar insolation. The DMM measuring voltage is connected directly to the module's terminals. The DMM measuring module current uses a shunt (10 Amperes, 10 milliVolt, 0.1% accuracy). A Fluke 80T-150U temperature probe is used to measure both module temperature and air temperature. A Li-Cor 200SB pyranometer measures insolation. This data was taken at Agate Flat, Oregon (42° 01' 02" N. 122° 23' 19" W.) at an altitude of 3,300 feet.

All modules are mounted on the same 6 foot by 12 foot rack, i.e. they are in the same plane. This assures equal access to sunlight. All modules were measured with the

Home Power's PV Test Jig



same instruments in the same places. Ambient air temperature was 27.4°C. (81.3°F.) to 31.7°C (89°F.) with a slight breeze blowing.

The Photovoltaic Players

Siemens
We used a brand-new, M55 Siemens module sent to us by its maker. This is a current production, single-crystal, PV module. This module contains 36 series connected square PV cells.

Solarex
We used a brand-new, MSX60 Solarex module sent to us by Dave Katz at Alternative Energy Engineering. The performance data of this multicrystal module is printed on its back. This data is the result of flash-testing of this specific module, not a "generic" rating like almost every other module. After flash-testing, a computer prints a label with the data for that specific module. This module contains 36 series connected square PV cells.

Kyocera
We used a brand-new, K51 Kyocera module provided by Bob–O Schultze at Electron Connection. This module contains 36 series connected square multicrystal PV cells.

Hoxan
We used a brand-new, 4310 Hoxan module provided by Dave Katz at Alternative Energy Engineering. This module contains 32 series connected square single crystal PV cells.

Carrizo
This module is a set of four ARCO M52 laminates wired in series to make a module. This seven year old module was suppled by Mike Elliston of Carizzo Solar. The resulting module of four laminates contains 48 series connected cells and a total cell count of 144 PV cells. The PV cells used to make these laminates are 3.75 inches square and are single crystal types.

Real Goods
This module is a set of four ARCO M52 laminates wired in series to make a module. This seven year old module was suppled by John Schaeffer of Real Goods. The resulting module of four laminates contains 48 series connected cells and a total cell count of 144 PV cells. The PV cells used to make these laminates are 3.75 inches square and are single crystal types.

Photocomm
This module is a set of three ARCO M52 laminates wired in series to make a module. This seven year old module was suppled by Ron Kenedi of Photocomm. The resulting module of three laminates contains 36 series connected cells and a total cell count of 108 PV cells. The PV cells used to make these laminates are 3.75 inches square and are single crystal types.

ARCO
This seven year old ARCO 16-2000 module was supplied by Wayne Robertson at Solar Electric Specialties. It has 33 series connected, single crystal, round PV cells.

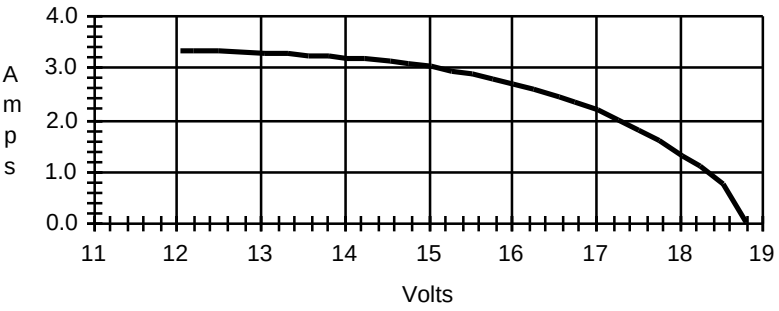
Sovonics
This is an amorphous silicon module supplied by Nick Pietrangleo of Harding Energy Systems. We've had this Sovonics R-100module out in the sun for the last 2 years.

The Data
We are content to let the data speak for itself. We used manufacturer's ratings at a 25°C. module temperature. In the comparison tables that follow this maker's performance specification is listed in the column called "Rated Value". Our measured data is in the column labeled "Measured Value". The column called "Percent of Rated" compares our measured results with the maker's ratings. The solar insolation data from the Li-Cor Pyranometer is accurate. At Agate Flat we often have solar insolation as high as 110 milliWatts per square centimeter.

Siemens - M55

	Rated Value	Measured Value	Percent of Rated	
Isc	3.35	3.42	102.1%	Amperes
Voc	21.70	18.79	86.6%	Volts
Pmax	53.00	45.14	85.2%	Watts
Vpmax	17.40	14.76	84.8%	Volts
Ipmax	3.05	3.06	100.3%	Amperes
PV Temp	25.00	50.00	200.0%	°C.
Insolation	100.00	108.90	108.9%	mW/sq. cm.

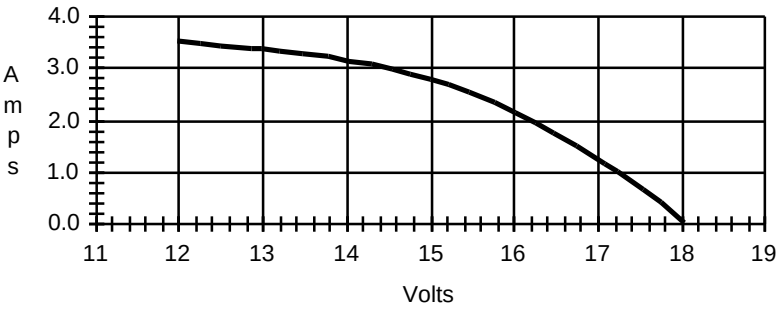
Siemens - M55



Solarex - MSX60

	Rated Value	Measured Value	Percent of Rated	
Isc	3.86	3.70	95.8%	Amperes
Voc	21.10	18.03	85.5%	Volts
Pmax	58.90	44.13	74.9%	Watts
Vpmax	17.10	13.80	80.7%	Volts
Ipmax	3.50	3.20	91.4%	Amperes
PV Temp	25.00	50.60	202.4%	°C.
Insolation	100.00	108.80	108.8%	mW/sq. cm.

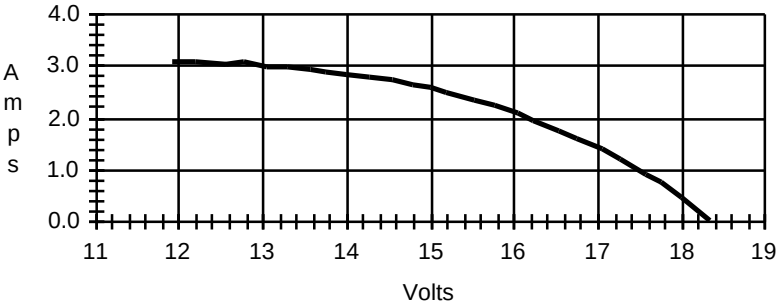
Solarex - MSX60



Kyocera - LA361K51

	Rated Value	Measured Value	Percent of Rated	
Isc	3.25	3.15	96.8%	Amperes
Voc	21.20	18.36	86.6%	Volts
Pmax	51.00	39.65	77.7%	Watts
Vpmax	16.90	14.02	83.0%	Volts
Ipmax	3.02	2.83	93.6%	Amperes
PV Temp	25.00	54.50	218.0%	°C.
Insolation	100.00	108.90	108.9%	mW/sq. cm.

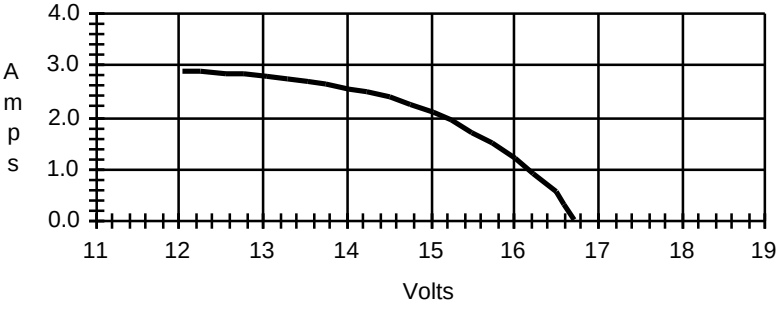
Kyocera - LA361K51



Hoxan - 4310

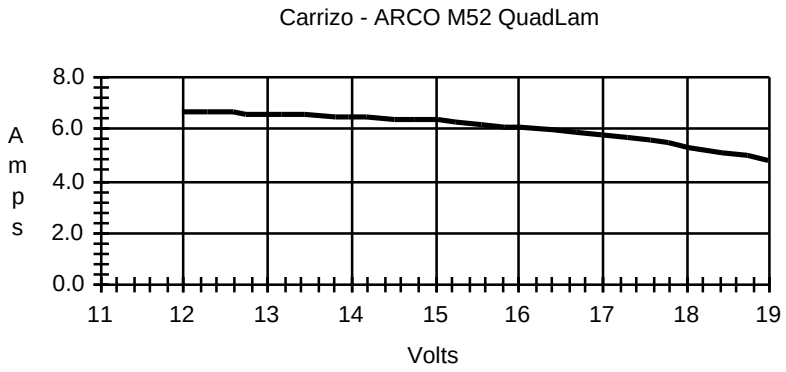
	Rated Value	Measured Value	Percent of Rated	
Isc	3.30	3.02	91.6%	Amperes
Voc	19.10	16.72	87.5%	Volts
Pmax	44.50	36.10	81.1%	Watts
Vpmax	15.00	13.56	90.4%	Volts
Ipmax	2.97	2.66	89.6%	Amperes
PV Temp	25.00	53.20	212.8%	°C.
Insolation	100.00	108.20	108.2%	mW/sq. cm.

Hoxan - 4310



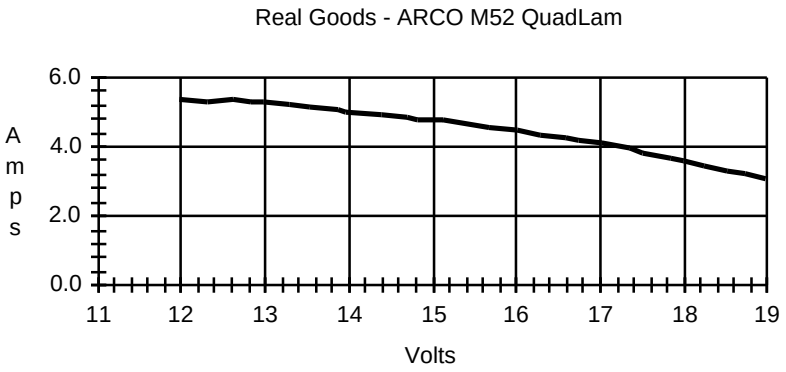
Carrizo - ARCO M52 QuadLam

	Rated Value	Measured Value	Percent of Rated	
Isc	6.00	6.72	112.0%	Amperes
Voc	25.00	24.36	97.4%	Volts
Pmax	105.00	96.94	92.3%	Watts
Vpmax	19.00	16.97	89.3%	Volts
Ipmax	5.50	5.81	105.5%	Amperes
PV Temp	25.00	51.30	205.2%	°C.
Insolation	100.00	107.70	107.7%	mW/sq. cm.



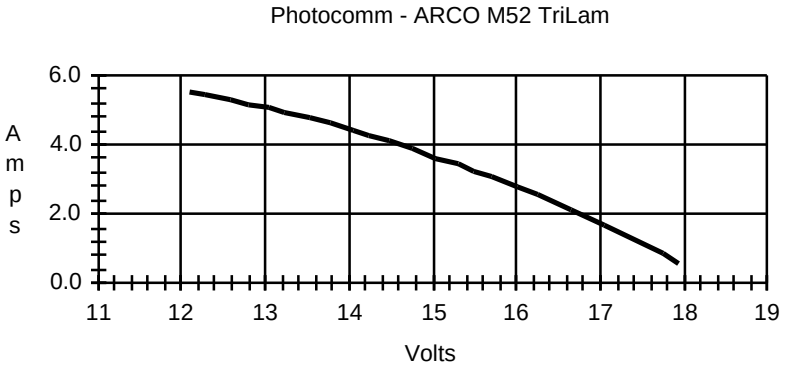
Real Goods - ARCO M52 QuadLam

	Rated Value	Measured Value	Percent of Rated	
Isc	5.50	5.98	108.6%	Amperes
Voc	25.00	23.61	94.4%	Volts
Pmax	100.00	71.39	71.4%	Watts
Vpmax	17.70	15.70	88.7%	Volts
Ipmax	5.60	4.55	81.2%	Amperes
PV Temp	25.00	52.50	210.0%	°C.
Insolation	100.00	106.60	106.6%	mW/sq. cm.



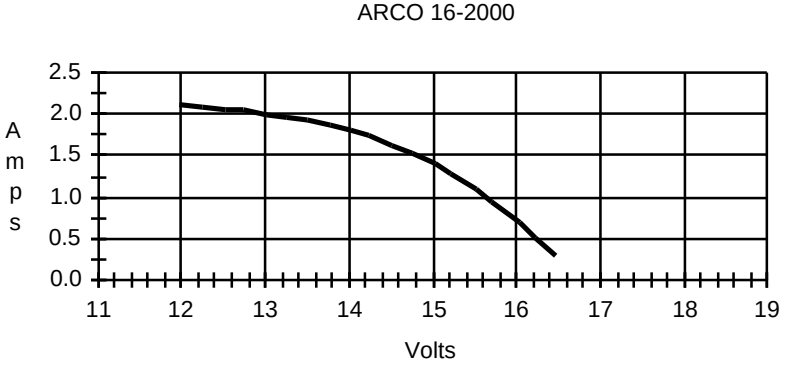
Photocomm - ARCO M52 TriLam

	Rated Value	Measured Value	Percent of Rated	
Isc	7.11	6.39	89.8%	Amperes
Voc	20.10	18.30	91.0%	Volts
Pmax	110.00	66.07	60.1%	Watts
Vpmax	16.50	12.29	74.5%	Volts
Ipmax	6.65	5.38	80.8%	Amperes
PV Temp	25.00	51.30	205.2%	°C.
Insolation	100.00	107.60	107.6%	mW/sq. cm.



ARCO 16-2000

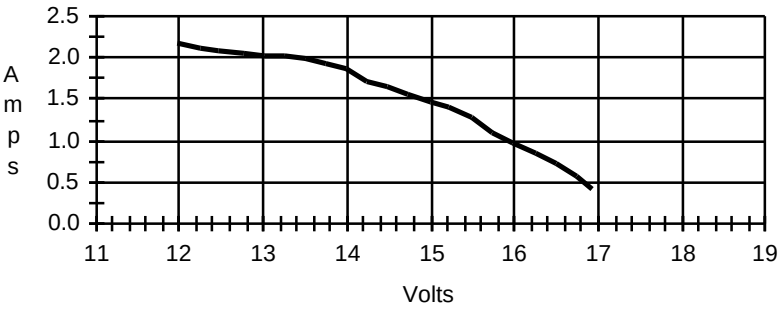
	Rated Value	Measured Value	Percent of Rated	
Isc	2.55	2.21	86.5%	Amperes
Voc	20.50	16.76	81.8%	Volts
Pmax	35.00	25.88	73.9%	Watts
Vpmax	15.50	13.04	84.1%	Volts
Ipmax	2.26	1.99	87.8%	Amperes
PV Temp	25.00	50.70	202.8%	°C.
Insolation	100.00	106.80	106.8%	mW/sq. cm.



Sovonics R-100

	Rated Value	Measured Value	Percent of Rated	
Isc	2.74	2.74	100.0%	Amperes
Voc	25.00	17.55	70.2%	Volts
Pmax	37.00	26.56	71.8%	Watts
Vpmax	17.20	13.51	78.5%	Volts
Ipmax	2.10	1.97	93.6%	Amperes
PV Temp	25.00	48.90	195.6%	°C.
Insolation	100.00	106.20	106.2%	mW/sq. cm.

Sovonics R-100



Conclusions

The 25°C. rating standard for PV module rating was poorly selected. Out in the sun, these modules are cooking at 50°C. or more. This causes voltage loss in the cells which in turn lowers the module's power output. If you live in a warm climate, then derate the maker's 25°C. power spec by 15% to 25% to compensate for module heating. A more realistic temperature for rating PV modules would be in the range of 40°C. to 50°C. because this is where most modules spend most of their operating lives.

We're not finished yet. We are going to continue testing modules out in the sun. We are going to do it on cloudy days, on freezing cold days, as well as the hot ones like today. We're going to test every module we can get our hands on. We invite you to do the same and send in your data for publication.

Access

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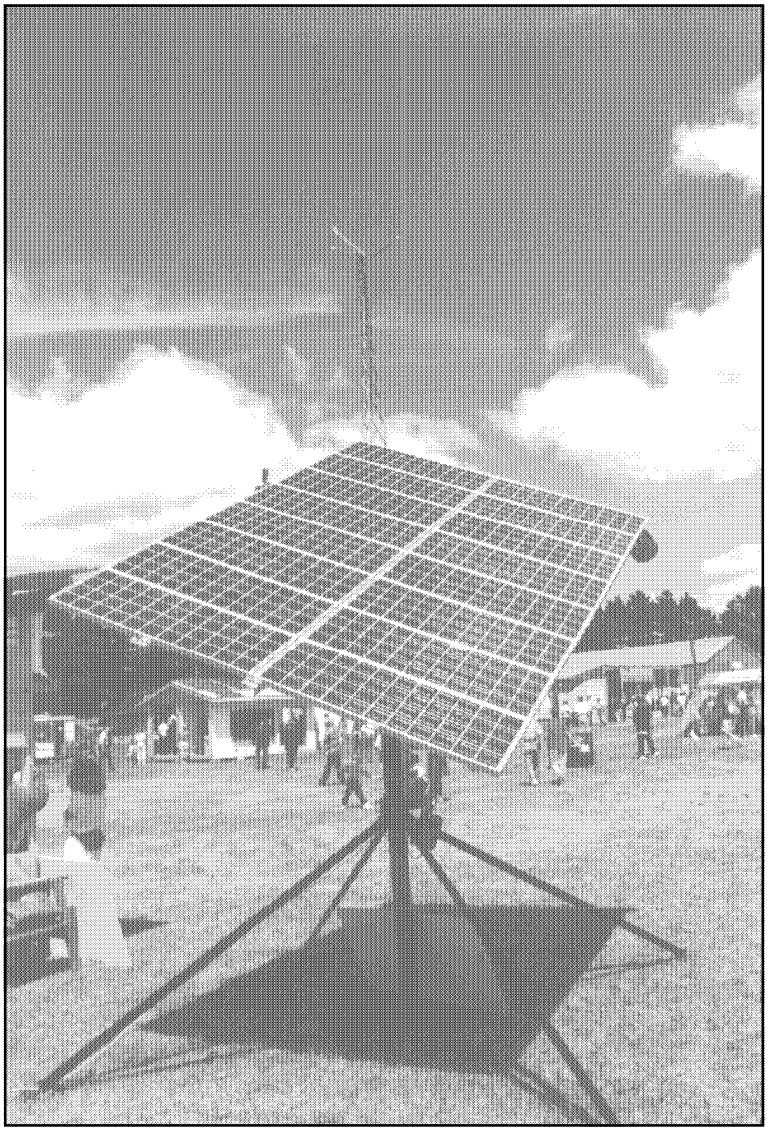
ELECTRON CONNECTION

The *Spark*

Richard Perez

The sun's power shines on us all. The understanding of this power is transmitted from person to person as a spark. I have felt this spark jump between the eyes of solar-powered people. Thousands of sparks massed together at the Midwest Renewable Energy Fair on this summer's solstice for a solar–powered explosion. The knowledge and understanding shared was incredible.



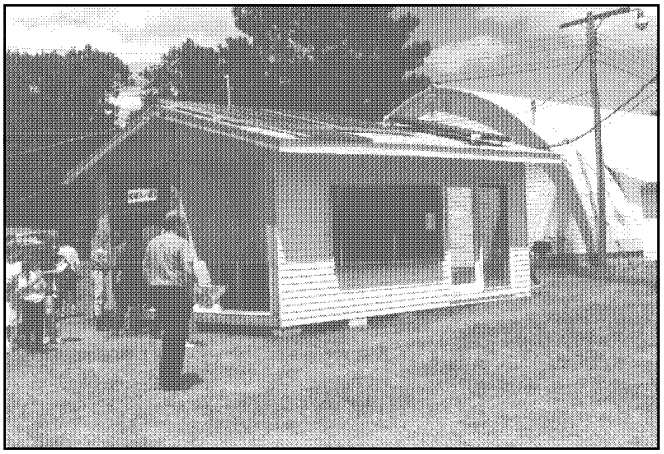
Above: sixteen 63 Watt PV modules on a Wattsun tracker. This array was part of a 120 Volt DC/ac system. Behind the array is Lake MI Wind & Sun's Jacobs feeding the demonstration home.

The Fair

The Midwest Renewable Energy Fair at Amherst, Wisconsin is an educational experience. Over the three fair days, some four to six thousand people attended. They came from far and wide to learn about using renewable energies in their lives and homes. There were 51 different workshop topics. These workshop sessions were like a four year course at Renewable Energies University compressed into a single weekend.

During the three day course of the Fair, 135 workshop meetings took place. Attendance at these workshops was heavy, from 25 to over 100 attendees per workshop. These workshops covered virtually every aspect of renewable energy. The workshops were conducted by hands–on people with years of practical experience in the subject. The amount of information changing brains was staggering.

In addition to commercial booths selling RE equipment, the MREF Folks set up a model home. This model home demonstrated the latest in thermally efficient building techniques. It employed a solar hot water heater, a PV array, and also used power from the Fair's big 24 Volt Jacobs wind machine. The house was divided into four areas. A bathroom displayed a low flush toilet and low voltage water pumps. A living room, complete with TV, VCR running energy videos, a computer, and printer was powered from the system. A kitchen with a locally made 24 Volt super efficient refrigerator/freezer. A power room full of all home power type goodies like batteries, inverters, controls and instruments. All rooms were lit by super-efficient fluorescent lamps. Hell, I wanted to ship the model home to Agate Flat and move in! The model home's Head Worker was Kurt Nelson



Above: the solar home at MREF '91 demonstrating solar electricity, wind power, solar hot water, and super efficient appliances.

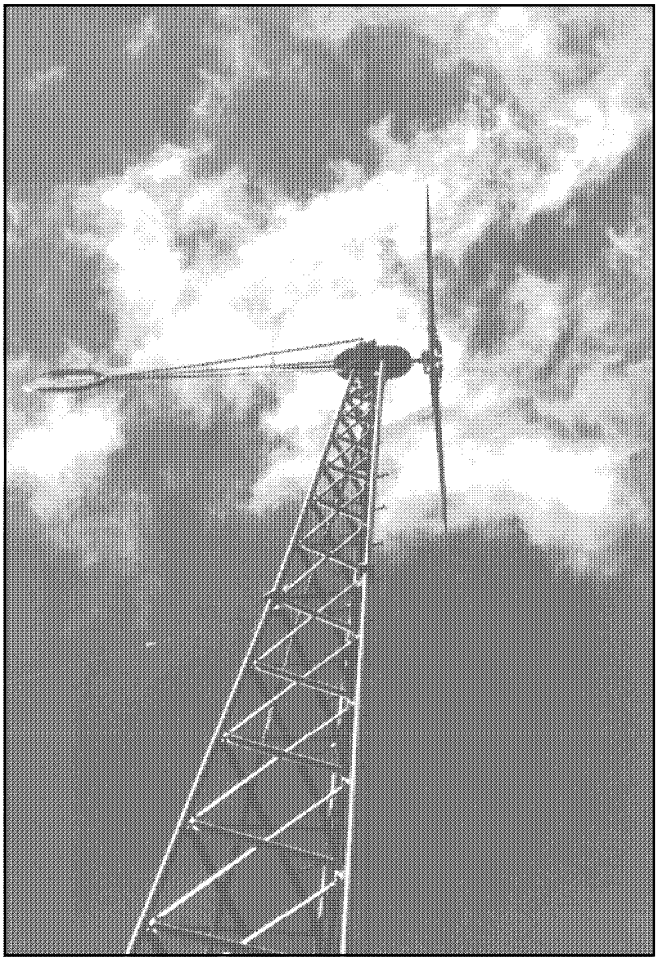
who gave two entire weeks of his life to the project (and without pay I might add). The local high-school shop class also helped with construction of the model home. Materials and equipment were donated by local businesses and individuals. It was a big hit with fair goers.

This year's Midwest Renewable Energy Fair was even better organized and attended than last year's. The Fair organizers put heart and soul into making the fair a high point of everyone's summer. I saw questions that had festered for years answered in a twinkling. I saw smiling people carrying lights, and inverters, and panels, and wind turbines out to their cars. I listened to solar powered music made by solar powered humans. I had too much fun. I saw the spark everywhere.

The Solar Technology Institute (STI)

We (Karen and I) shared a booth with the nonprofit Solar Technology Institute. Here, we spent many hours discussing solar education and solar projects for the developing world. In Ken, Johnny, Peter, and Linda of STI, we have found friends who are dedicating their lives to spreading the spark. These guys not only run the best hands-on, solar education courses in the world, but also do vast amounts of good work with solar power in developing countries.

Karen and I have accepted positions on the Advisory Board of the Solar Technology Institute. I will be teaching, with Ken and Johnny, the advanced PV course at STI from 23 September to 3 October 1991. We are very proud and pleased to be able to donate our energies to this fine project. So all you PV types, I'm looking forward to some great sessions with you at STI this fall. See page 49 of this issue for the details.



Above: the big Jacobs supplied much of the power used at the fair's workshops. The tower is eighty feet tall.
Below: Ken Olson (center) and Johnny Weiss (right) of

Jordan Energy Institute
Jordan folks not only attended the Fair, they also brought their solar car, the Sunseeker, with them. Jordan continues with their fine renewable energy and electric vehicle programs. I spent some time crawling around their solar car and was amazed at the level of technology displayed there. By the time Detroit gets their EV act together, the Jordan crew will be flying around in PV-powered heliocopters.

Solar Educators
Drs. Robert and Sonia Vogl of Solar Solutions were displaying their PV education kit. This kit consists of a PV module mounted and wired on a plexiglass case. There are also meters and terminals for various experiments to be performed with the PV module. The kit was very well constructed with all wiring visible for children to see. The manual and lesson plan were extensive and understandable. The kit alone is good enough, but coupled with the manual and lessons, the kit is educational dynamite. Robert and Sonia have tried their kit on fourth to sixth grades with amazing results. Kids learn the concept of solar power quickly when it is presented in easy to understand ways like the Vogl's PV kit. I can only hope that educational systems around the nation have the common good sense to use kits like this one in their schools.

New Products at MREF
I saw several new products displayed for the first time. The new Wattsun tracker was used on two large PV arrays. Chad Lampkin of Michigan Energy Works mounted sixteen Kyocera 63 Watt modules on a Wattsun, dual axis tracker. The folks at Midway Labs operated their new concentrator PV modules (160 suns!) mounted on a Wattsun dual-axis tracker. This new electric tracker is fascinating to watch. It uses 10 to 20 Watt-hours of power daily to keep the modules exactly perpendicular to the sun. And I mean exactly (definitely within 0.25° on both the NS and EW axes). The Wattsun tracker uses two electric linear actuators (employed on satellite dishes) to track the sun.

Being there…
The atmosphere was charged with discussion. A giant network of renewable minds exchanged data as fast as synapses would allow. People walked out with RE products bought on fair specials. We only got rained on once. I don't know when I've had a better time.

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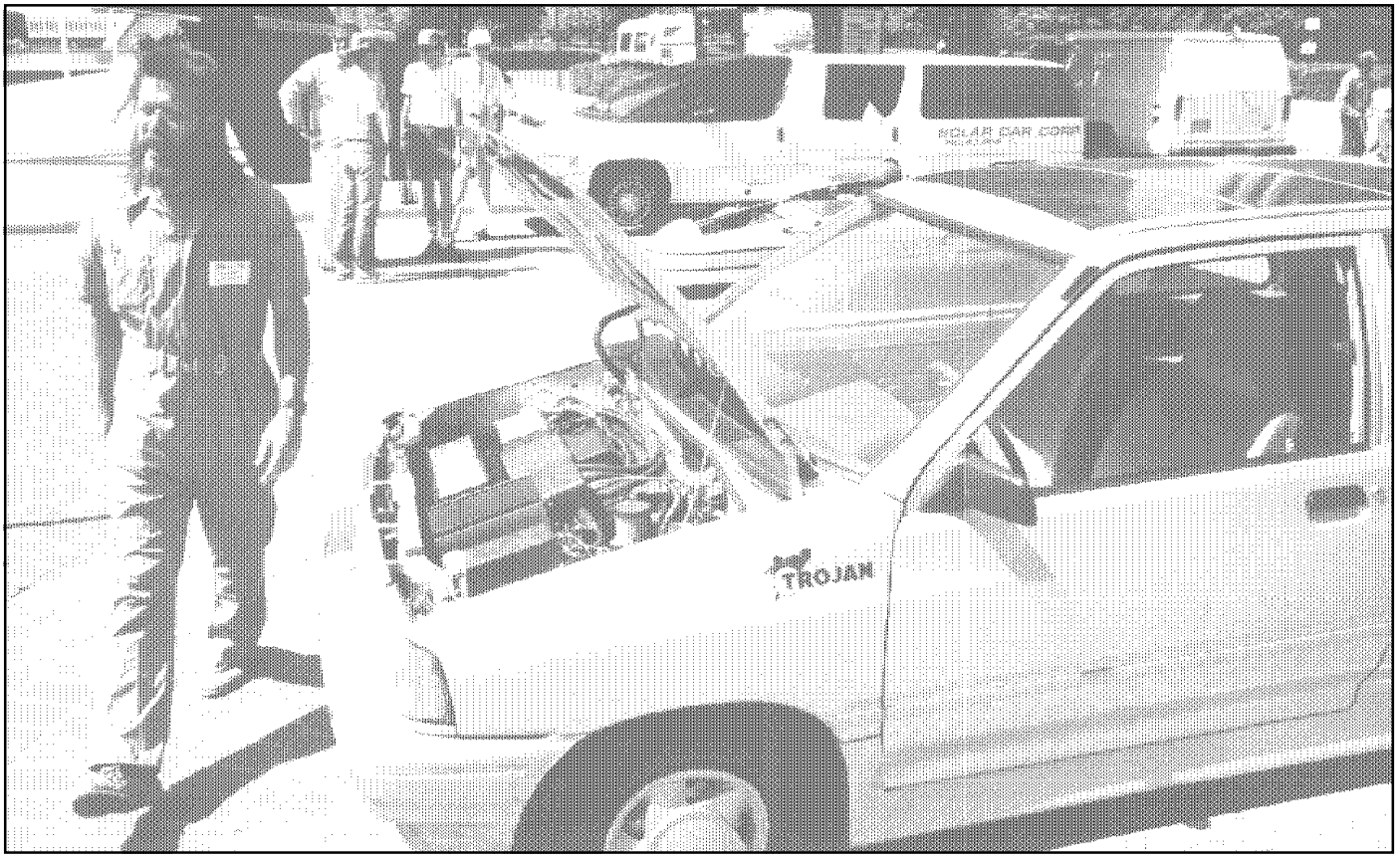
Jordan Energy Institute, 155 Seven Mile Road, Comstock Park, MI 49321 • 616-784-7595

Solar Solutions (PV Education Kit), 1230 East Honey Creek Road, Oregon, IL 61061 • 815-732-7332



Above: Doug Cobb, President of Solar Car Corp of Melbourne, Florida walking by his well built Festiva Solar Electric. Solar Car Corp is actively marketing both electric and solar electric models. Photo by C. Michael Lewis

1991 American Tour de Sol

Robert Wills

The five day 1991 American Tour de Sol Solar/Electric car race started at Rockefeller Plaza in Albany, New York, on May 20. Governor Mario Cuomo said, "Energy and environment are a single concern. ...When we learn to use energy wisely we will reduce pollution, and cure acid rain and global warming". He then sent the twenty-six entrants on their way with a wave of an Earth Flag.

The Route

The race travelled east from Albany to Plymouth Rock, MA. The first Tour de Sol Earthfair was held at Plymouth.

The cars took five days to travel the 247 road miles of the race. The average run of 50 miles per day emulates typical commuting and is within the reach of teams with limited technical and financial resources. In addition, cars can run optional laps each day to demonstrate their range. The winning commuter car, Solectria Corporation's Flash, travelled an extra 108 miles in laps, averaging 71 miles per day.

About the Tour de Sol

The 1989 American Tour de Sol was the first multi-day solar car race in the U.S.A. The Tour de Sol differs from speed races. Its main aim is to promote solar and electric commuter vehicles. Solar racing cars do serve a purpose – they push the limits of technology and pose very different design and racing problems. The main aim of the

American Tour de Sol is to bring solar and electric vehicles into widespread, everyday use.

Another purpose of the race is to promote renewable sources of energy. An electric vehicle still pollutes (albeit less than internal combustion vehicles) if its source of energy is a conventional power plant. The answer is to use renewable sources of energy - wind, hydro, and photovoltaics. It is not practical to carry a PV array on a commuter car that is large enough to provide a full daily charge, but efficient vehicles can gain 10 to 30 miles in range from vehicle mounted photovoltaics. We see the long term solution as having some photovoltaics on vehicles, but getting most of our power from grid-connected distributed PV on roofs nationwide. Photovoltaics on a car do serve three purposes – they show that PVs are a viable, available technology; they provide some measure of additional range, and especially with lead-acid batteries, they provide a slow topping up charge that can greatly extend battery life.

The third aim of the Tour de Sol is education. Thousands of people come to see the cars, and millions learn of them through mass media. They learn alternatives to gasoline powered cars and fossil fueled power plants. The people who make the cars also learn a lot - building a solar car is a demanding, real-world project.

Tour de Sol Car Categories

Commuter Vehicles have to carry a driver and passenger and are allowed a maximum of 720 Watts peak of photovoltaics and 7.2 kWh of battery storage. The are allowed to recharge their batteries fully from the power grid each night, to emulate normal commuter use. Vehicle mounted photovoltaics are optional - it is possible to run a pure electric vehicle in the race.

There are two categories of racing vehicles: Tour de Sol Racers are limited to 480 Watts peak of PV array and 4.8 kWh of battery storage. Cross-continental Racers are built to the rules of the cross-Australia World Solar Challenge and are limited only by a maximum PV area of 12 square meters. Both racing categories must travel each day using only power generated from their PV arrays. (They are allowed to start the race with full batteries though).

The Open category is for any other vehicle conforming to the aims of the event. These range from production electric vehicles with more battery storage than the commuter category allows, to PV powered mountain bikes and mopeds.

Notable Vehicles

There were two basic types of commuter vehicles entered. Some were converted gasoline cars such as Solectria's Force and Force GT (originally Chevy Geos) and New Hampshire Technical Institute's Sungo (based on a Yugo). New England Institute of Technology's Solar Tech is a converted BMW Izetta. Mattatuck Community College's Sunbird is a beautifully converted 1952 vintage MG replica. Others are build from the ground up for lightness, aerodynamics and efficiency. The winning car, Solectria's Flash has a fiberglass frame with a fiberglass/kevlar skin and weighs only 1000 pounds with driver.

In the racing categories, MIT's winning entry, MIT V, is the epitome of lightness and aerodynamic design. Dartmouth's new Sunvox IV featured an aluminum frame with a fiberglass body and composite front suspension members. Conval High school (Peterborough, NH) again entered their four wheeled Sol Survivor with its kevlar monocoque body. In the cross-continental category, Rochester Institute of Technology's Spirit with an aluminum frame and foam/dacron skin came in first.

The open category had many interesting cars ranging from Solar Car Corporation's beautifully converted Ford Festiva's, to the Rosebud team's solar electric mountain bike. The winning car in the open category was the Electric Hilltopper from St. Johnsbury Academy, Vermont. Their converted 1979 VW Rabbit ran a perfect race and demonstrated a range of one hundred miles on the last day. A great performance by a highschool team. The total cost of their vehicle was $4,000.

Technology

Most commuter cars used 10 to 20 Horsepower series motors made by Prestolite, Advanced DC motors or General Electric with Curtis PMC controllers. Exceptions were the Solectria cars, the Sungo and the Solar Tech which used 11 horsepower Solectria brushless dc motors. There is an interesting tradeoff between the simplicity of dc brush motors and the efficiency and lightness of brushless motors as the the brushless controllers are much more complicated and expensive. On the whole, the reliability of the electric drive systems was excellent.

Racing category cars, going all out for performance, generally used brushless dc motors from Solectria, Uniq Mobility or General Electric.

Most of the converted commuter vehicles kept a gear box in the drive train from motor to wheels. Notable exceptions were the Solectria cars and NHTI's Sungo which has two Solectria motors connected via chain drives to each rear wheel. All of the racing vehicles used a direct drive, taking advantage of the wide torque range of their electric motors.

Batteries are well known as the limiting factor in electric vehicle performance. Most cars in the Tour de Sol used deep cycle lead acid batteries made by Trojan, Keystone or Sears. The winning commuter, Solectria's Flash used SAFT nicad cells while NHTI's Sungo had Hoppecke fiber nicads. The racing category cars either used lead acid cells, or if budgets allowed, super light-weight silver-zinc and silver-cadmium cells.

The use of silver based batteries is rather controversial because they are too expensive for large scale electric vehicle production. For this reason, silver batteries may not be allowed in future Tour de Sol races.

Photovoltaic modules on cars ranged from the carefully integrated Photocomm/Kyocera laminates on the Solar Car Corporation cars to the many cars using Solectria/Siemens laminates which are made in Switzerland, to the Solarex SX30s on the Sungo, to the cell by cell arrays formed to the curves of the cross-continental racers.

Vehicle Testing

A full day of testing was done on the Sunday before the race. As vehicle safety is paramount, no vehicle can compete in the Tour de Sol without it. Vehicles were tested for compliance with the rules, especially PV array and battery bank size. The mechanical inspection is for practicality, safety and stability and includes a cone test and starting on an incline. The braking test is stringent (better than -5 m/s2 for a four wheel vehicle) as all vehicles are carrying a considerable load of batteries. An acceleration test was done to determine pole position. All vehicles must be street legal, registered, insured and capable of sustained speeds of 25 mph or more.

Probably the most interesting testing that was done was vehicle efficiency. By measuring average battery voltage and current over a known course, we could calculate the average Watt-hours per mile used. A very simple clip-on instrumentation system was used – one Fluke 87 meter measuring voltage and another, via a Fluke 80i-1010 dc clamp probe, the current. The fluke meters can calculate true average values over a period of up to 36 hours. The results of the test (see table) show excellent consistency by vehicle type: Most of the racers ranged from 47 to 58 Wh/mile, commuters typically around 160 to 200 Wh/mile and the heavier open category cars ranging from 230 to 260 Wh/mile. Cars that deviated dramatically from these numbers either had errors in measurement, or drove with a very different style to others in the test. In particular, the low energy usage of the Force GT can be attributed to careful driving and the use of regenerative braking.

Results

Placings of the 26 entrants are shown in the table. Scoring for the American Tour de Sol uses "adjusted time". This is the route running time minus an allowance for each optional lap, plus any time penalties incurred for rule infractions or not completing a leg.

Winning teams received cash prizes and trophies. The top three student teams in the commuter and open categories shared $10,000 in prize money provided by the U.S. Department of Energy, our major sponsor. There are also DOE prizes for the best student videos of the race. Other sponsors included the NH Governor's Energy

1991 American Tour de Sol Results

Place	Name	Team	Total Miles	Adj. Hours	Usage W-h/Mi.
Commuter Class					
1	The Flash	Solectria Corporation	355	7.25	60.00
2	The Force	Solectria Corporation	247	9.40	296.30
3	Sunbird	Mattatuck Comm. College	259	13.53	182.20
4	Solar Tech	New England Inst. of Tech.	218	26.88	163.70
5	Sungo	New Hampshire Tech. Inst.	143	44.55	184.80
6	SunDriver D	SunDriver Inc.	121	60.75	222.70
7	S-CAR-GO	Delta College	44	72.38	N/A
8	Independence	Svenson Brothers	0	84.33	
Tour de Sol Racing Class					
1	Solectria V	MIT Solar EV Club	302	7.32	55.40
2	Solaray	Virginia Tech. Inst.	263	9.68	47.70
3	Suntech	NH Technical Institute	258	9.88	56.00
4	Sol Survivor II	ConVal High School	247	11.12	
5	Sunvox IV	Dartmouth College	229	20.98	50.30
6	Solarflame	Univ. of Illinois, Chicago	132	49.07	98.68
7	Nuspec Phoenix	Northeastern University	45	73.25	N/A
Cross Continental Class					
1	Spirit	Rochester Inst. of Tech.	243	15.17	N/A
2	Wild Solarcat II	Villanova University	161	40.90	58.80
3	SunDragon II	Drexel University	99	56.17	
Open Class					
1	Electric Hilltopper	St. Johnsbury Academy	304	8.38	261.00
2	Force GT	Solectria Corporation	269	14.97	123.20
3	Poetry in Motion	Albert Hutton	244	19.07	296.20
4	Festiva Solar	Solar Car Corporation	223	23.30	250.80
5	Festiva Electric	Solar Car Corporation	178	33.47	282.80
6	EVA-EL 1	Peter Systems	130	58.60	234.00
7	Rosebud 2	Team Rosebud	112	60.68	N/A
8	Sunpacer	Cato-Meridian HS	10	82.08	N/A

Office, the NY State Energy Office, the New England Electric System and the Nathan Cummings Foundation.

A Major Step towards Sustainability
The American Tour de Sol is organized by the Northeast Sustainable Energy Association (NESEA). Just last year we changed our name from Solar Energy to Sustainable Energy to better reflect our aims. The use of solar energy is just one facet of a sustainable future.

It seems that a new environmental disaster emerges every year. First there was acid rain, then global warming, then air pollution in cities, gasoline in groundwater, ozone depletion, and now oil wells burning in the Middle East. All of these are caused in part by automobiles. In addition, oil reserves are dwindling, and will not last more than another generation.

The oil age has lasted just 100 years and is ending in environmental disaster. We need sustainable energy technologies that last not 100 but 1000 years – or even 1000 generations – without harming the environment. Harry Braun's book "The Phoenix Project" is a good overview of sustainable energy options. He concludes that solar energy is the only viable alternative.

In the broader picture, we need sustainability in energy, transportation, resource use, and agriculture - a sustainable society. Electric vehicles offer a step beyond the frustration of being able to do little more than recycling paper and containers. Put PVs on your roof and an EV in your garage, and you have taken a major step towards living in a sustainable society.

ATdS Symposium & the 1992 Race
The Tour de Sol Symposium will be in Boxboro, MA, (just west of Boston) this Oct. 26 & 27, and will feature displays of commuter and racing solar/electric vehicles, and sessions on vehicle design, components, policy and economics. The keynote speaker will be Robert Stempel, CEO of General Motors Corporation. The car display will be open to the public.

Planning of the 1992 race is now under way. We expect more cars, more publicity, and an even better time for the participants. As always, we are looking for the support and volunteers that make these events possible. If you would like to help with the Tour de Sol, please contact us.

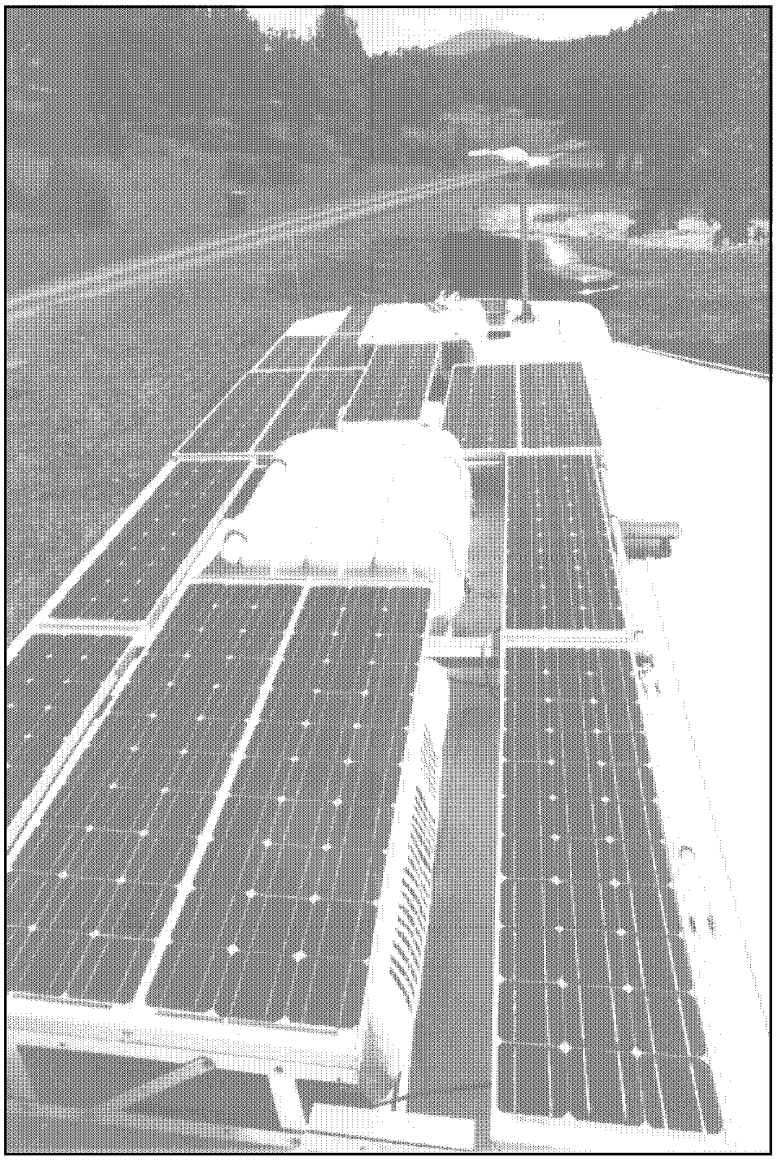
Access:
American Tour de Sol, Northeast Sustainable Energy Association, 23 Ames St, Greenfield, MA 01301 • 413-774-6051

The Phoenix Project, Research Analysts 1990, POB 62892, Phoenix, AZ 85082 • 602-969-3777.

Down the road with PVs

Richard Perez

How many photovoltaic modules can you fit on the roof of a recreational vehicle? Well, this one holds fifteen panels. The system's owner, Brint Gilbert, is using this RV to find his country home. And when Brint eventually finds his homestead, he will know where his power will come from.



Above: Brint installed fifteen photovoltaic modules on the roof of his motorhome. This PV system makes this RV electrically independent without using a generator. When this RV is at home, it powers some of Brint's home.

The Mission

Finding a suitable place for a homestead is not easy. In early 1970, we put 14,000 miles on a truck looking for our homestead. We drove from California to Maine and back again. We traveled the back roads crossing the largest blank spaces we could find on maps. After six months of ceaseless travel, we got lost and found our homestead on Agate Flat, Oregon. This is Brint's mission.

The RV carries Brint and his mother in solar-powered style as they search for their country home. When they find their home, then the PVs and system components come off the RV to be installed in their new homestead. Meanwhile, when Brint is at his present home in Mesa, Arizona, he plugs into the RV and uses its solar power to run some the appliances his downtown home.

The RV's Appliances

This is an all electric RV. PV supplied power is used for cooking, water heating, air conditioning, refrigeration, entertainment electronics, and lighting. Appliances aboard Brint's motorhome are detailed in the table below.

Resting in the driveway…

When Brint's RV is not on the road, it sits in his driveway with a power cord stretching into Brint's grid connected home. Brint has taken many of his downtown appliances off of the grid and powers them from solar electricity made by the resting motorhome. Some of the appliances powered at home by the RV are: a 24 inch Color TV for 16 hours daily, a 900 Watt microwave oven for 45 minutes daily, three Osram compact fluorescents five hours each daily, three ceiling fans for ten hours daily, and occasional use of a clothes iron, a washing machine, a sewing machine, and a vacuum cleaner.

PV-powered Appliances in Brint Gilbert's RV

Appliance	Watts	On time hrs / day	W.-hrs. per day
Refrigerator	275	7.00	1925
Microwave Oven	1200	0.60	720
Water Heater	750	0.75	563
9" Color TV	25	10.00	250
Toaster Oven	1200	0.20	240
Lights	45	5.00	225
Fans	50	3.00	150
Vacuum	600	0.10	60
Average daily power consumption			4133

The RV's Hardware

All this electricity is produced by fifteen ARCO M75 PV modules each rated at 47 Watts. Total peak PV power is about 750 Watts and the array produces about 4,000 Watt-hours daily. This power is stored in six Trojan T-125 lead–acid batteries. Total storage is 705 Ampere-hours at 12 Volts DC. PV power is controlled by a 50 Ampere SCI charge controller. The system also uses a Trace 2012 inverter with battery charger to supply the 120 vac powered appliances.

The installation of all this power equipment on and in an RV could not have been easy. Brint's installation is immaculate. Each panel has its own hand fabricated aluminium mounting brackets. The panels are mounted in the free spaces between the two roof mounted air conditioners and all the other stuff found on RV roofs. Nowhere is there a dangling wire or funky connection. When I walked up to the RV, I couldn't see that the panels were even on the roof!

The batteries are tucked into a slide out compartment accessible from outside, just behind the pilot's seat. Here they are outside of the living compartment, secure and easily maintained. The inverter and controls are tucked under one of the couches in motorhome's forward cabin. Once again the installation is totally ship shape.

A Rolling Solar Power House

No matter where Brint goes in his motorhome he will always have electric power. Brint is often surrounded by curious RVers trying to find out how he's running his air conditioner and everything else without a generator. Brint mentioned that it's great to have the conveniences without having to listen to a generator yammering as it gave the entire RV a vibramassage.

When Brint settles down, he already has his power system and several years of PV living experience.

Access

System's Designer and Installer: Brint Gilbert. 6409 East Desert Street, Mesa AZ 85205.

Author: Richard Perez, C/O Home Power, POB 130, Hornbrook, CA 96044 • 916-475-3179.

Instrumentation for Home Power Systems

Richard Perez

When we make our own electricity we are our own power company. We are our own production crew, our own energy auditor, and our own trouble shooter. Instruments are our eyes into the electric world of our power systems. Without accurate instruments we are flying blind. While instrumentation is not necessary for the system to work, it greatly helps us operate our systems. And when things don't go right, instrumentation is essential for finding out what and where the problem is.

System Measurement

If we don't know how our system is performing, then we cannot effectively use it. We are in the same position as a U Boat captain, we must make operational decisions based on the state of charge of our batteries. If the batteries are full and the power source producing, then we are wasting power in the only way possible in an RE system– by not using it. If the batteries are empty, then we need to ease power consumption.. So battery state of charge is the first and most important bit of info we need.

Monitoring critical system points gives us an at a glance check of major component performance. We don't really need to continually know this data everywhere in our system, just at critical points. The best places to make these mostly voltage and current measurements are on power producers (PV, hydro, wind, or ?), power storage (batteries) and power processing devices (inverters and controls).

Before we measure anything, we need a meter. It could be an analog meter (you know, the older types with a dial and pointer) or a more modern type that displays numbers on a digital display. The instrument may be set up to perform many types of measurements or it may be optimized to perform only one. How accurate does the instrument need to be? As accurate as you can afford. In measurement, accuracy is the name of the game.

A Good DMM vs. Discrete Instruments

A Digital MultiMeter (DMM) can make a variety of measurements. The DMM will measure voltage, current, and resistance. Some DMMs will also measure frequency, duty-cycle, capacitance, test semiconductors, and record data in their memory. There are hundreds of these meters on the market. We use two Flukes at Home Power. The Fluke 77 is rugged, accurate (0.1% on DC), and inexpensive (≈$140). The Fluke 87 has all the features mentioned above for about $280. These are highly accurate, capable, and reliable instruments. If you are seriously interested in instrumentation, a DMM of this caliber should be your first purchase. It will be the standard with which you will build other specialized, dedicated instruments. There are less expensive DMMs than the Flukes mentioned here. You will get what you pay for. The higher quality DMMs are more accurate, have many more features, last many times longer, and are very rugged. See HP#15, page 41 for a technical report on the Fluke 87 DMM

Discrete analog meters are inexpensive and usually optimized to perform a single function, like being a battery voltmeter. The accuracy of analog meters can vary from "strictly ballpark" (as bad as ±25%) to very accurate (≈1%). Analog meters are inexpensive ($3 to $40) and easily available in the surplus market. They are powered by the circuit under test and generally require no on board batteries. They are extremely easy to tweak into accurate, dedicated meters for virtually any measurement.

So the choice of instruments is up to you. Let your inclination and bank account be your guide.

Battery Measurements

The battery is the heart of the system. The battery is the Numero Uno, first, last, and most essential component subjected to continuous scrutiny. The best single instrument for operating batteries is a dedicated battery Ampere-hour meter. Period. If you don't really care about fully instrumenting your system and want only a single instrument, then get a battery Ampere-hour meter.

Other very useful battery instruments include a dedicated battery voltmeter and a bi-directional ammeter that measures net current into and out of the battery. We use both and find them very informative for at a glance checks on system performance.

Battery Ampere-hour measurement
The constant question in any battery based system is, "How full is the battery?" The easiest to understand and most accurate method uses a digital Ampere-hour meter. It's a "gas gauge" for all types of batteries, both lead-acid and nickel-cadmium. These instruments not only work well, but their information is direct and understandable by even the most nontechnical battery user.

Ampere-hour Measurement
There are many ways to measure a battery's State of Charge (SOC). In lead-acid cells, you can measure the specific gravity of the electrolyte with a hydrometer. But this is temperature dependent and risks contamination. In nicads, specific gravity of the electrolyte is meaningless as it doesn't change with the cell's state of charge. We can use a voltmeter to determine SOC. But this is not very accurate, and varies with the battery's temperature. Measuring SOC by voltage is also dependent on the current flow through the battery. If the battery is under charge, then the voltage is higher. If the battery is under discharge, then the voltage is lower. And after you have compensated the voltage measurement for current and temperature, then you must still consult a SOC versus Voltage chart to accurately determine the battery's State of Charge. Sound confusing? Well, it is. And all this confusion is cleared up by an Ampere-hour meter.

Ampere-hour measurement is the best way to determine battery state of charge. The measurement doesn't depend on temperature, cell type, or whether the battery is being charged or discharged. The Ampere-hour meter provides a digital readout of exactly how many Ampere-hours have been withdrawn from the batteries.

Ampere-hour meters come in two types. Some are totalizing types that continually add up the Ampere-hours flowing in a single direction, say the yearly current production of a PV array. Other Ampere-hour meters are optimized as Battery SOC meters, and are bi-directional, net reading meters. They measure and count current flow to and from the battery.

The Ampere-hour Meter- a "Gas Gauge" for Batteries
The battery Ampere-hour meter is installed on a fully charged battery. At this point the digital display will read zero (0). This makes sense since the battery is full and we haven't yet withdrawn any power from it. As the battery is discharged, the digital display counts the Ampere-hours withdrawn from the battery. For example, say our battery is full in the afternoon and during the night we withdraw 40 Ampere-hours. In the morning, the Ampere-hour meter will read -40 (that's MINUS 40) to indicate that we've withdrawn 40 Ampere-hours from the full battery. As the Sun comes up and the PV array (or any other power source) starts recharging the battery, the Ampere-hour meter begins counting up (from -40, it counts to -39, -38, -37, etc.) to zero as the battery refills. When the battery is full, the meter again reads zero. At that point any additional recharging of the battery is read as positive numbers on the display. For example, after the battery is full, if we put 20 Ampere-hours more through it, then the display will read 20 as "overcharge Ampere-hours". After charging stops, the meter resets itself to zero regardless of the number of overcharge Ampere-hours. This makes sense since overcharge Ampere-hours can not stored by the battery because it is already full.

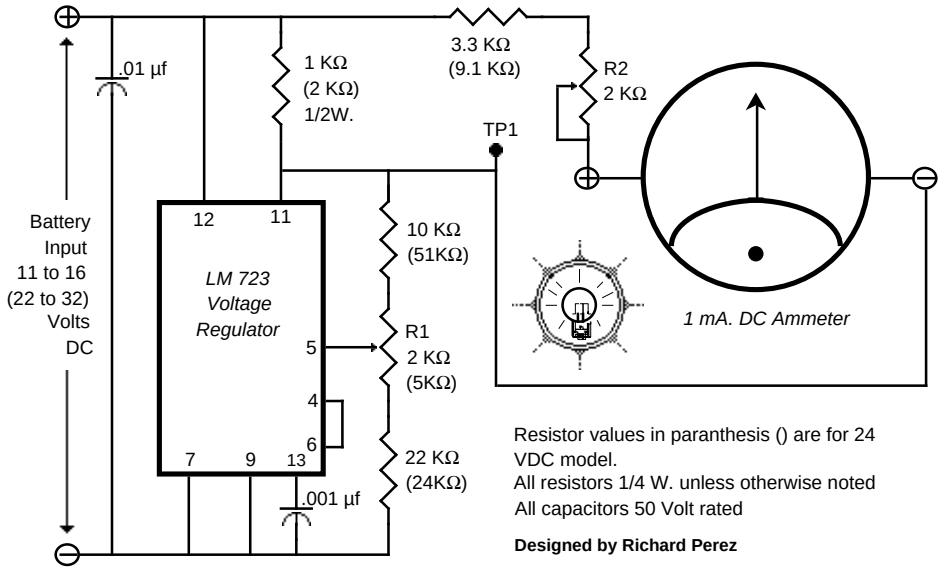
For "Things that Work!" tests of two battery Ampere-hour meters see HP#16, page 40 for a review of Cruising Equipment's meter. See HP#20, page 40 for a "Things that Work!" review of the Ample Power's Ampere-hour meter. The Cruising Equipment model is a straight Amp-hour meter for about $200, while the Ample Power version is also a battery voltmeter and battery ammeter for about $300.

Battery Voltage
Let's face it, although battery Ampere-hour meters are the best tool for the job, they are also expensive. Many of us still use battery voltmeters to aid us in determining battery state of charge. If you own a DMM, then you can use it to measure battery voltage. Most of us, even those with several DMMs, still like to have a dedicated battery voltmeter on line. You can buy these as digital meters for around $50, as analog meters for about $20, or you can make a very accurate analog model as follows.

The Expanded Scale Analog Battery Voltmeter
The idea here is to use an analog dc milliammeter to accurately measure battery voltage. This circuit produces an expanded scale voltmeter. Most analog voltmeters start reading a 0 volts. This is really a waste for battery systems as a lead acid battery will have about 10 to 11 volts (20 to 22 VDC in a 24 VDC system) even when just about empty. So the portion of the meter's scale between 0 and 10 volts is never used. Wasting this portion of the meter's scale decreases its resolution and thereby the accuracy of the meter. This circuit allows the meter to start reading at 11 volts and to display full scale at 16 volts (a very fully charged 12 Volt battery while still under charge). The 24 VDC version starts reading at 22 VDC and displays full scale at 32 VDC. This is called an expanded scale, and makes the meter much more accurate to use.

Expanded Scale Analog Battery Voltmeter

11 to 16 VDC (or 22 to 32 VDC)



Resistor values in paranthesis () are for 24 VDC model.
All resistors 1/4 W. unless otherwise noted
All capacitors 50 Volt rated

Designed by Richard Perez

All the components for this meter are available at most Radio Shack stores, or from just about any electronics supply house. Cost of the parts should be between $15. and $40., depending on your hardware sources. Construction time is about 1 hour for an experienced assembler. This circuit is powered by the battery under measurement.

We don't have space here to give an electronics primer for those not familiar with electronic construction. What I do offer is the schematic for the circuit. If you can't figure out how to build this meter from the schematic, then please seek out an electronics person who can aid you.

Electronic Nitty-Gritty

This circuit uses a 1 mA. DC Ammeter as an expanded scale voltmeter. The meter has its ground elevated to 11 Volts (22 Volts in a 24 VDC system) by the use of an LM 723 voltage regulator in shunt mode. This makes the meter very accurate as there are no series semiconductors in the measurement circuit. Full scale reading and the 11 Volt (or 22 Volt) ground level are both adjustable by using the potentiometers in the circuit. R1 adjusts the shunt regulator. Adjust R1 until Test Point 1 (TP1) is at 11 Volts (22 VDC in a 24 Volt system). Then adjust R2 until the meter reads the battery's voltage at the time. Use an accurate DMM to calibrate this circuit.

Average power consumption is about 5 milliWatts. When on line 24 hours a day, power consumption is less than 0.1 Watt-hours per day. This meter is super–efficient and can be left on line all the time with a minimum of power consumption. We've had one on line since 1976.

Battery Current

A bi-directional Ammeter is a great instrument to have. The instrument measures current into or out of the battery. Since the ammeter is in series with the battery, the ammeter must have low insertion loss. Every amperage measurement scheme has some electrical resistance. At the high currents commonly found in battery systems, the insertion resistance must be low (less than 0.001 Ω). For example, an inverter starting a big electric motor may require over 800 Amperes of current from the battery. All this current must pass through the ammeter.

Shunts

In high current situations, use a shunt for measuring battery current. Shunts are very low resistance, precision resistors designed specifically for current measurement. Shunts are relatively inexpensive ($10 to $40), accurate (0.1%), and can handle large currents (10 A. to >1000 A.). Shunts are used for current measurement by every Ampere-hour meter and most ammeters. If you can live with accuracy losses <10%, then you can use the copper wiring in your system as shunts. It all works by the magic of Ohm's Law.

In Theory

Ohm's law tells us that any electrical current flowing through a material (like a piece of wire or a shunt) suffers a loss in voltage. This voltage drop across the material is due to its resistance and the movement of the electrons (current) through that material. The amount of current flowing through the material can be determined if we know two things. One, the voltage loss across the material, and Two, the resistance of the material. Or in algebraic terms using Ohm's Law:

$$I = E / R$$

where

I= the amount of current in Amperes

E= the voltage drop in Volts

R= the material's resistance in Ohms

Everything in the system is wired with copper wire. The wiring is necessary to move current from place to place. If we consider these wires as resistors, then we can use the

voltage loss across a wire to determine the current flowing through the wire.

How it Works

All we need to perform current measurements is a Digital MultiMeter (DMM) and the already existing wire in our systems. And help from Ohm's Law.

The DMM is used to measure the voltage drop across a piece of wire carrying current. The DMM should be capable of making measurements in the millivolt DC range. Such resolution is necessary as this technique involves using lengths of wire with resistances from 0.01Ω to 0.0001Ω. The resultant voltage drops across such small resistances will be low, and we'll need a DMM that can make accurate measurements in the milliVolt range.

We also need to know, as accurately as possible, the resistance of the piece of copper wire we are using. To find this resistance first determine the wire's size or gauge. Most wire has its gauge number printed on its insulation. Or the wire's gauge can be determined by using a wire gauge measuring tool. Once the gauge number is known, then measure the length of the wire. Copper wire has its resistance, in Ohms per foot, specified by gauge number. Once we know the gauge, we can look up the resistance (Ω/ft) on a Copper Wire Table. This value is multiplied by the number of feet of wire we are using to make the measurement. And the result is the resistance of that particular piece of copper wire or shunt.

This technique can be used on wire of any size, and of any length. There are certain resistance values for shunts that have distinct advantages. Consider the following resistances: 0.01Ω, 0.001Ω, and 0.0001Ω. If these values are used for R, then we are performing division by a decimal fraction of 1. This means that the measurement taken by the DMM can be read directly and a calculator is not needed to perform the math. Only the decimal point of the reading of the DMM need be shifted to obtain the amperage measurement.

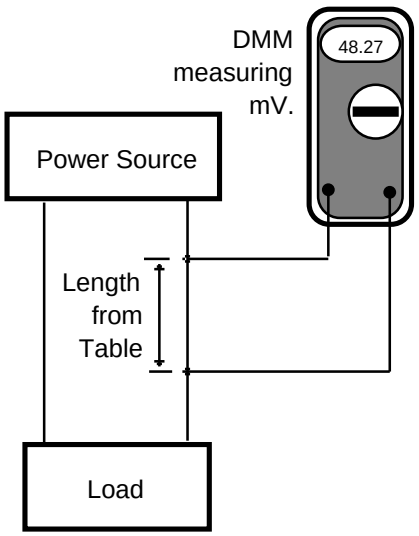
What follows is a Copper Wire Table that is optimized to display the lengths of various gauges that have resistances from 0.01Ω to 0.0001Ω. Find the wire gauge size of the wire you are using, and the lengths necessary to produce the shunts are shown across the table. Measure the indicated length along your wire and you have a shunt with a resistance that is a decimal fraction of 1. Attach the leads of the DMM across this length and you're ready to make current measurements.

At the head of each shunt column on the table, there is a reminder to shift the decimal point on the mV. reading taken from the DMM. For example, let's consider a 12 VDC light hooked up with 12 gauge wire. From the shunt table, we see that 0.63 feet of this 12 gauge wire will give us a shunt of 0.001Ω. The heading of the column tells us that the milliVolt (mV.) reading on the meter will equal the amperes of current through the shunt. If we measure 4.2 mV. across this 0.001Ω shunt, then the current flowing the shunt (and the light) the light is 4.2 Amperes. If the shunt had a resistance of 0.01 Ω (as in 6.3 feet of 12 ga.), the the milliVolt reading on the DMM would be 42.0 mV. and would have to be divided by 10 to produce the correct amperage measurement of 4.2 Amperes.

Copper Wire Shunt Table

	mV / 10 = Amps		mV = Amps		mV X 10 = Amps	
Gauge	0.01 Ω		0.001 Ω		0.0001 Ω	
Size	Feet	Meters	Feet	Meters	Feet	Meters
OOOO	203.95	62.164	20.40	6.216	2.04	0.622
OOO	161.74	49.299	16.17	4.930	1.62	0.493
OO	128.27	39.097	12.83	3.910	1.28	0.391
O	101.73	31.006	10.17	3.101	1.02	0.310
2	63.98	19.500	6.40	1.950	0.64	0.195
4	40.24	12.264	4.02	1.226	0.40	0.123
6	25.31	7.713	2.53	0.771	0.25	0.077
8	15.92	4.851	1.59	0.485	0.16	0.049
10	10.01	3.051	1.00	0.305	0.10	0.031
12	6.30	1.919	0.63	0.192	0.06	0.019
14	3.96	1.207	0.40	0.121	0.04	0.012
16	2.49	0.759	0.25	0.076	0.02	0.008
18	1.57	0.477	0.16	0.048	0.02	0.005
20	0.99	0.300	0.10	0.030	0.01	0.003
22	0.62	0.189	0.06	0.019	0.01	0.002

Using a DMM and a Shunt to measure current



The schematic below shows the electrical setup for using shunts to measure current. Measurement can be made on the positive or negative wire, it doesn't make any difference. I've made switch panels to measure current in different places

by soldering small (20 gauge) "sense" wires to the shunts (either commercially made high accuracy shunts, or just plain ole' copper wire ones) and running these smaller wires to a panel with a rotary switch. The DMM is connected to the output of the switch which selects the different shunts. We don't have to cut the wire to make a shunt. Simply make the length measurement, strip back the insulation at the shunt's length, and solder on the sense wires. In places where you don't need to make measurements often, use needle probes on the DMM to pierce the insulation without stripping. A piece of string is useful to transfer length measurements from a tape to stiff pieces of nonstraight wire and cable.

Where to Use Copper Wire Shunts

Use this technique any place you wish to measure current. Here are some suggestions. On the main wires delivering current from PV arrays to the batteries. On the wires that supply current to an inverter (this is a great place for a 0.0001Ω shunt made out of 2.04 feet of 0000 gauge copper cable). On the wires that connect the battery pack to the bus. And on any appliance whose current consumption needs to be measured.

Advantages

There are all kinds of advantages in using this technique. The wiring that we are using to make the measurement already exists to move the power to or from the device. The measurement process doesn't introduce any new losses as the shunt wiring is already there. The wiring need not be cut as in the insertion of an in-line meter. Shunts can be made with very low resistances, thus enabling high current measurements with minimum loss. The technique can be used with minimum trouble and no expense for occasional measurements than don't require a dedicated in-line ammeter.

Disadvantages

The big disadvantage is inaccuracy due to the copper wire changing resistance as it heats or cools. The information on the Copper Wire Shunt Table is correct for copper wire at 68°F. (20°C.). For copper wire at 32°F. (0°C.), this method will yield amperage measurements that are low by about 10%. At a wire temperature of 122°F. (50°C.), this method yields amperage measurements that are high by 10%. If you compensate for the temperature of the wire, this technique can be made more accurate.

For high accuracy, use a factory made shunt instead of the copper wire shunt. Commercial shunts are made from materials whose resistance varies only slightly with temperature. Commercial shunts are also calibrated and tested for accuracy.

Inverter measurements

In many of our systems all the power consumed passes through the inverter. Since the inverter plays such a crucial role, it is a very good place to make provisions for measurement. In some cases you may wish to use a dedicated meter. For example, I use an old surplus ($2) Weston analog ac voltmeter to constantly measure our inverter's voltage output.

Inverter Input Current

This is a place for a shunt. My favorite for this location is a Deltech model (50 milliVolts at 500 Amperes with surge to 1,000 Amperes). This shunt is massive, has very insertion loss (0.0001Ω), costs about $25, and has massive terminals with large bolts.

If you don't need the accuracy of a precision shunt, then use the copper cable that connects the inverter to the battery as a shunt. Since this cable is in place anyway, measure off a shunt length anywhere along one of the inverter's cables, nick the insulation, solder the sense wires, and measure away!

Inverter Output Voltage

Inverters produce nonstandard ac waveform. Only certain types of instruments can accurately measure modified sine-wave inverter voltage or current output. These instruments will be specified to measure "True RMS voltage". For example the Fluke 87 will accurate measure an inverter's output. The Fluke 77 will not, and so won't most every DMM costing less than $200. We are interested in not only the RMS voltage of the inverter (should about 117 vac ±5%), but also the peak voltage of the inverter's waveform. Peak voltages should be within 15% of ±164 vac, and the plus and minus peaks should measure within two volts of each other.

Oddly enough older analog meter will measure inverter output voltage with fair accuracy. For example, the old Weston iron-vane ac voltmeter I mentioned works OK (±3%). These meters are too slow and stupid to notice the fine differences between sinusoidal ac (like from a utility) and modified sine-wave power (from an inverter). These older analog types are usually not phantom loads and will allow the inverter to go to "sleep" at night.

Inverter Output Current

The same rap about True RMS reading instruments applies to accurate measurement of the inverter's current output (ac amperage) also. A precision shunt or a copper wire shunt are used for this purpose with a True RMS DMM. Also analog ac meter movements are fairly accurate when used to measure inverter output current.

Power Source Current

We use a 50 milliVolt, 50 Ampere precision shunt inline with our PV array. This shunt allows us to measure the current output of our array with a DMM. This same shunt also functions with our Thomson & Howe recording Ampere-hour meter. This Ampere-hour meter has been on line for years now and totalizes the output of our array. We record its data daily in a notebook. This data has allowed us to very accurately measure long term PV performance in our neighborhood. See HP21, page 39 for a "Things that Work!" report on this recording Ampere-hour meter.

Other power sources like hydros and wind turbines can also have current instrumentation. Once again, use a precision shunt or at least a copper wire shunt. After all, the wire has got to be there anyway, and it's simple to use it as a shunt. My experience with RE power sources shows me that operators are always curious about how much current is being produced.

Are we done yet?

No, when we get hooked on measurement, we're never done. From where I sit typing this in, I can see six digital meters and twelve dedicated analog meters. And I have three more meters waiting to be installed. I'm so badly hooked on data that I even write down the measurements in daily logs and then compile the data yearly on the computer. I obviously have an advanced case of data dementia. I am not suggesting that all home power producers get involved this deeply (although it's fun and educational).

Better use of our power comes from understanding and knowledge. Instrumentation gives us ability to measure the invisible electron's activity. Measurement is the key to our understanding and use of power.

Access

Author: Richard Perez, C/O Home Power, POB 130, Hornbrook, CA 96044 • 916-475-3179.

DMMs: John Fluke Mfg. Co., POB 9090, Everett, WA 98206 • 800-443-5853.

Surplus Analog Meters: Fair Radio Sales. POB 1105, Lima, OH 45802 • 419-223-2196. Also, C and H Sales Co., 2176 E. Colorado Blvd. Pasadena, CA 91107 • 800-325-9465 or 213-681-4925.

Shunts: Deltech, 13065-H Tom White Way, Norwalk, CA 90650 • 213-926-2304.

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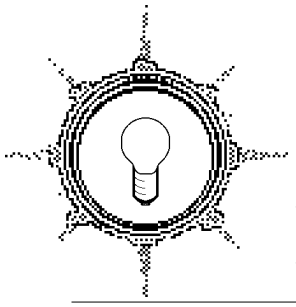

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HP#24

Lightning Protection

Mick Sagrillo

What a sight to behold! You're the proud owner of a new wind system. You and a bunch of dedicated friends labored all weekend to get the tower up, the wind generator in place, and the wiring completed. And now it's done. The wind is crankin' and she's pumping amps through the inverter. But wait! What's this? The sky is blackening! Everything has gone still! Lightning is striking the ground fast and furious on the horizon! And it's all coming your way!!!

Send a chill down your spine? Good! It was meant to. Too often, lightning protection is an afterthought, if it's thought at all. While lightning protection should be considered in the planning stages of any renewable energy project, certain measures can be retrofitted at any time. Whatever stage you're at, plan now, before the great electrons in the sky start eyeballing your tower!

NOTE: While this article is about wind generators, the principles can applied to any renewable electric system.

Know your enemy

The surface of the earth carries a negative charge, while the ionosphere is positively charged. What we have here, on a global scale, is one great capacitor. Under certain circumstances, this "mother of all capacitors" will discharge. We call these occurrences thunderstorms. At any given time, 2000 to 3000 thunderstorms are in progress somewhere around the earth.

For a cloud to ground discharge to occur, what we call lightning, the electrical resistance of the atmosphere has to be overcome. The electrical potential necessary to jump from ten to a hundred miles is on the order of hundreds of millions of volts. The current in a bolt of lightning averages 20,000 amps. The amount of energy in a single lightning strike is about 100 million joules. Suffice it to say that this is enough energy to melt a ton of copper in about one tenth of a second.

Double Trouble

There are two problems associated with lightning. The obvious problem presented by thunderstorms is a direct lightning strike to the tower and wind generator. Lightening is looking for a path to ground, and a wind generator tower, being tall and a conductor, helps it out. A second but lesser known problem is the electrostatic transients caused by a nearby strike that can be set up in towers, generators, and wiring. These transient voltages can be just as damaging to generators and electronic equipment as a direct lightning strike.

When lightning strikes near a wind generator, a current can be induced in towers, wire runs, and utility and telephone lines. These induced currents can set up voltage spikes that are very harmful to electronic equipment associated with wind generators, such as inverters and control boxes. In addition, the voltage spikes and induced currents can degrade wire insulation in the wind generator and tower wiring over time, resulting in shorts to ground.

Both problems need to be addressed, but in different ways.

Lightening Rods

In my part of the country, we have many houses and barns constructed with "tin" roofs. Back in the '30's, a door-to-door lightning rod salesman would come around and hawk his wares. The idea was to put up a lightning rod that was well grounded to earth to take the lightning strike, rather than the tin roof. This was supposed to keep your house or barn from burning down. These lightning rods work, but not for the originally conceived reason.

Remember that the earth carries a negative charge. This negative charge extends to all objects on the earth, such as houses, barns, and towers, as well as all things living on the earth, such as trees and people. Lightening rods work because they bleed off any static charge that builds up on whatever they're attached to. This is good! If a given surface has less of a static charge, it is less attractive to lightning. The important part of a lightning rod is not the rod itself, but the grounding system. A lightning rod is only as good as its ground!

Grounding Towers

Wind generators and towers are made of metal. Metal has a low resistance, or low impedance, to the flow of

electricity. They are excellent conductors. They are, therefore, a logical path for lightning to follow in getting to the earth. All towers should be grounded.

A ground is simply a metal rod driven into the earth. This rod is attached to the tower by a heavy gauge wire. A properly installed ground will bleed off any static charge present on the wind generator and tower making a direct strike less likely, as well as conducting a direct lightning strike to the earth where it belongs. Upon being hit, the entire tower structure will shunt or discharge the energy in the lightning harmlessly into the ground.

Commercially available grounding rods are 8' long steel rods coated with copper. If bedrock is less than 8' below the surface, drive the ground rod at an angle, rather than shorten the rod. This will maximize the surface area of the rod in contact with the earth.

The wire used to connect the rod to the tower should be either a very thick single strand of copper wire, or stranded wire with a few strands of heavy gauge copper wire. A few heavy strands of wire are preferable to many fine strands of light gauge wire, such as the type used for welding cables. This is due to the fact that the copper is going to oxidize and corrode. Fine wire, having a larger cumulative surface area, corrodes much faster than heavy wire. Corroded wire between a grounding rod and a grounding rod and a tower will soon cease to exist, and along with it any grounding protection. Some countries prohibit the use of stranded wire for lightning grounds. For the same reason, aluminum wire should never be used for grounding purposes.

Ideally, the copper grounding wire should be physically bonded to both the ground rod and the tower. This can be done by brazing or silver soldering the metals to one another. Because few people have this capability, most folks choose to use some sort of clamping device to connect the ground rods and tower. Make sure that these clamps are made of either brass or copper. Dissimilar metals should avoided where ever possible. When wet, dissimilar metals act as a very weak battery. It is speculated that this galvanic phenomenon may actually attract lightning strikes.

Keep the grounding wires as short as possible. We want to make it easy for the lightning to reach the earth. For the same reason, avoid sharp kinks in the grounding wire between the tower and ground rods. Lightening likes to follow a straight path. If possible, run the grounding wires in the same line as the tower legs. If this is impractical, then bend the grounding wires in a very gentle curve from the tower leg to the ground rod.

Make sure you ground all of the tower legs of a freestanding or guyed tower. This not only guarantees adequate grounding but also prevents second guessing which piece of your real estate will provide the best ground. If you have a guyed tower, ground the guy wires where the guy anchors enter the soil.

Moist Earth First!-the organization for radical grounders

We all know that a wind generator tower should be grounded. But not all grounds are created equal! The purpose of a grounding system is to provide a low impedance path for lightning to follow to earth. And not just any earth, but moist earth! Moist earth conducts electricity much better than dry earth does. The Institute of Electrical and Electronic Engineers categorize soils for the purpose of grounding as shown in the table.

Average Resistivity of the Ground

Type of Ground	*Resistivity Ω – meter*
Wet organic soil	10
Moist soil	100
Dry soil	1000
Bed rock	10000

What this chart tells us is that when your soggy spring-time soil dries out in August, you loose 9/10th's of your grounding protection! It also means that someone with drier, rockier soil will only have 1/10th the grounding protection of another person with wetter soil, given the exact same grounding systems. What to do?

Extend the grounding system. This can be done by connecting the ground rods together with bare copper wire buried below the soil's surface. You can even build a grounding grid with a network of concentric wire rings. The more elaborate the grid, the more surface contact you have between the grounding system and the earth. If you have a well nearby, run a ground wire over to the well casing. Wells, being in constant contact with water, make excellent grounds.

A trick that is often used to increase the conductivity of the soil is to dig a hole with a post hole digger where you intend to locate a ground rod. Dig the hole a deep as you can. Then drive the ground rod in the center of the hole. Mix the soil from the hole with salt, then replace the soil/salt mixture back into the hole around the ground rod. The salt adds electrolytes to the soil, making it much more conductive than it was originally.

Other things to ground...

Your inverter, control box, and battery rack should also be grounded inside your house. A water pipe will always make a good ground. A dedicated ground rod for this

equipment is even better. Use only one ground rod with all connecting wires from individual electronic equipment running to it. This will eliminate lightning flashing over from a poor ground to a better one right inside your house.

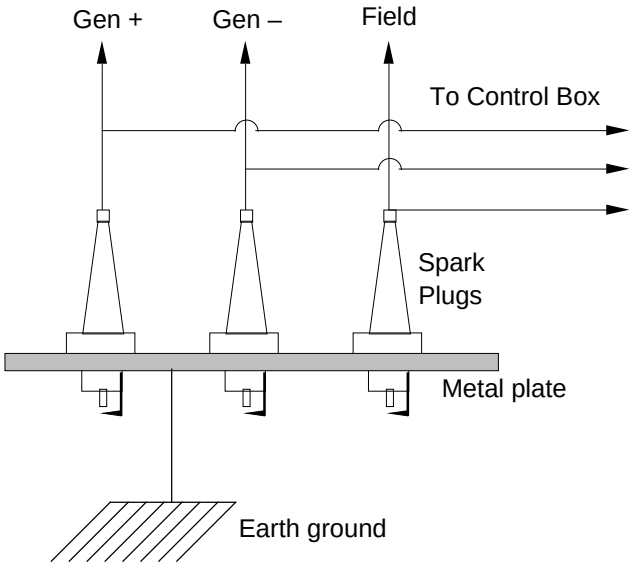
...And not to ground
NEVER, UNDER ANY CIRCUMSTANCES, GROUND ANY ELECTRICAL SYSTEM TO A GAS PIPE OR AN OIL PIPE.

Also, I DO NOT recommend that either the positive or negative leg of a wind electric system be grounded. (I realize that this is heresy to some, because it's "the law" of the National Electric Code. But I would remind readers that many "laws" have been reversed. An excellent example is the water hook-up law in Chicago. Tens of thousands of Chicago homes still have a 1" lead water pipe connecting the house to the water main. For obvious reasons, this practice has been discontinued. I rest my case on blindly following "laws".) For one thing, these wind generators constitute "floating" systems. Connecting one leg of a DC source of electricity to ground will result in what is known as a "ground loop" or "ground fault". A synchronous inverter connected to the DC electricity of a wind electric plant will short out with a ground fault present, blowing the SCR's.

Another reason NOT to connect a DC leg to ground is that an electrolytic reaction will take place between the generator and ground. Back in the the 30's, some manufacturers of wind electric plants would connect the negative leg of the generator to ground, thereby eliminating one slip ring and brush. The negative was then picked up at the tower base and carried to the batteries. After five or ten years, these towers would fall over. Close inspection revealed that the metal at the soil line was soft and spongy. What happened was that the electric current present in the tower leg set up a weak battery with the earth. Ever so slowly, various metal ions would disassociate from the tower and migrate into the earth. The result was usually sudden and always catastrophic. For the same reason, I do not recommend permanently grounding any battery bank. However, for safety considerations, a battery bank should be temporarily grounded while working on it. (More on this from myself and others ion an upcoming article.)

"Spark" Arrestors
In 1935, a patent was issued for a "spark gap" type of lightning arrestor. The purpose of these arrestors was to shunt a lightning strike traveling down the tower wires safely to ground before it reached the battery bank. While still commercially available, this type of arrestor is easily fabricated, as follows.

An automotive-type of spark plug is needed for each wire to be protected. The gap of the spark plug is widened to about 1/8". All of the spark plugs used should be mounted onto one metal plate and placed inside of a weatherproof metal enclosure, like a Hoffman box. The metal mounting plate should be grounded with wire in a straight line down to a ground rod. The wind generator wires should come into the Hoffman box from the top and be connected to the terminals of the spark plugs. From there, the wind generator wires take a sharp right angle bend out of the Hoffman box and continue on their way to the battery bank.



The idea behind the spark arrestor is that lightning likes to run in a straight line ground. The spark plugs, connected in a direct line to ground, provide that path. Lightening, traveling down the tower wiring, would rather jump the 1/8" gap and continue to ground than make a right turn.

Lightning Arrestors
The modern version of the spark arrestor is called the silicon oxide varistor, or SOV. In an SOV, current-carrying electrodes are insulated by silicon oxide, a material related to sand. The silicon oxide is rated to insulate against a given voltage. With high voltages, the silicon oxide is changed from an insulator to a conductor. The lightning bolt is shunted safely to ground. When the voltage returns to its normal level, the silicon oxide changes back to an insulator. Unless the bolt of lightning is strong enough to blow them completely apart, SOV's

can be used forever. While not cheap, they are the most effective lightning protection that can be added to a system. SOV's can be used on both AC and DC systems.

Disconnects
The most effective way of preventing lightning from playing havoc with your batteries and electronic equipment is to physically disconnect them from the tower wiring. This must be done right to work properly.

I once connected a kilowatt-hour meter on the AC side of one of my wind generators for this purpose. The idea was that I could remove the meter from its socket and thereby prevent lightning from getting into my inverter. My opportunity came with the next thunderstorm, and I rushed down to the cellar to pull the meter from its socket. A moment later, lightning hit my tower, and right before my eyes, I saw the current arc across the terminals of the meter socket. I foolishly thought that the five inch gap left by the removal of the meter would stop a lightning bolt that had just traveled ten miles or so across the open sky!

Needless to say, any system using a gap IN A STRAIGHT LINE will not work. This means that a disconnect switch or large knife switch is useless. What does work, however, is to use an electric range or dryer plug and cable on the inverter end, and a matching outlet on the generator end. If the outlet is level with or higher than the plug and cord, then the plug and cord will dangle harmlessly away from the outlet when unplugged. While it is a pain to unplug your wind system whenever a thunderstorm rolls by, this system works for high strike locations and it's cheap.

Transients
Remember that when lightning strikes the area near a wind generator (or a utility or phone line), electrostatic pulses are induced in wires & towers. These pulses are known as voltage transients, and can be as high as several thousand volts. Transients can damage wire insulation and electronic components as they bounce around inside generators and inverters trying to dissipate their energy. While they can be just as harmful as lightning, transients are much easier to deal with.

Shielding
The best way to keep transients out of your renewable energy system is by shielding the wires. Shielding begins on the tower. ALL wires should be run down the tower in metal conduit (EMT-electrical metal tubing). Plastic conduit won't do. The conduit should be grounded. Electrostatic pulses from lightning will run through the conduit safely to ground, never making it into the tower wiring. If you have a metal tower with tubular legs, you can run the wires through one of the legs & eliminate the conduit.

By grounding the chassis or metal boxes that your inverter and controls live in, you also shield them from lightning-induced transients.

MOVs
An effective way to shunt transient voltage spikes to ground is to use metal oxide varistors, or MOV's. An MOV is a device that will bleed off transients above a given voltage that are bouncing around electronic circuitry or AC power lines. The gang plugs/surge suppressors sold by electronics stores for TV, stereo, and computer equipment are chock full of MOV's. They are fast, cheap, and available at most electronics outlets. Anyone connected to the utility grid should add MOV's to sensitive equipment, i.e., your synchronous inverter.

The Static Brush
Wind generator blades will develop a static charge as they pass through the air. Rotating electrical equipment also builds up a static charge. Wind generators have both! As stated earlier, it is speculated that this static charge may actually attract lightning. The best way to dissipate static charges is to connect the rotating armature, rotor, or blades to ground. This is done with a static brush.

A static brush is merely a carbon or metal graphite brush fitted onto the generator shaft so that the brush runs continuously on the rotating generator shaft. The other end of the static brush is grounded. This continuous ground works to eliminate static charges from building up.

Static brushes are also used to bypass generator and yaw bearings and thereby prevent static charges from dissipating through the bearings and pitting them.

For Further Reading...
Anyone interested in an in-depth dissertation on lightning and wind electric systems should rush out and order a copy of "How To Protect A Wind Turbine From Lightening", Final Report; by C.W. Dodd, et al; University of Southern Illinois, Carbondale;1983; NASA-CR-168229.

Access
Author: Mick Sagrillo avoids being zapped at Lake Michigan Wind & Sun, E 3971 Bluebird Rd., Forestville, WI 54213 (414) 837-2267.

muddy roads

Clive Ellis

In the earliest years of my homesteading career I simply plugged my house trailer into my Jeep battery to run some 12 volt lights for a few minutes each evening. I used a propane lamp to light the main living space until I developed a working micro hydroelectric generator, after much trial and error in building my own Pelton wheel. For a while I still used the jeep battery for power and ran the hydro generator intermittently to charge the battery when necessary. The hydro unit was put away for the winter when I left for the season.

When I came back the following spring I didn't get the hydro generator out right away as I had numerous other chores to tend to, and wasn't using the 12 volt lights very much (I thought). When it was time to drive to town for supplies several days later, the Jeep wouldn't start.

Well no problem, I'll just get out the hydro-gen and recharge the battery. Then I discovered that I had taken the Pelton wheel off the generator to show to a friend in town last winter and had forgot to bring it back.

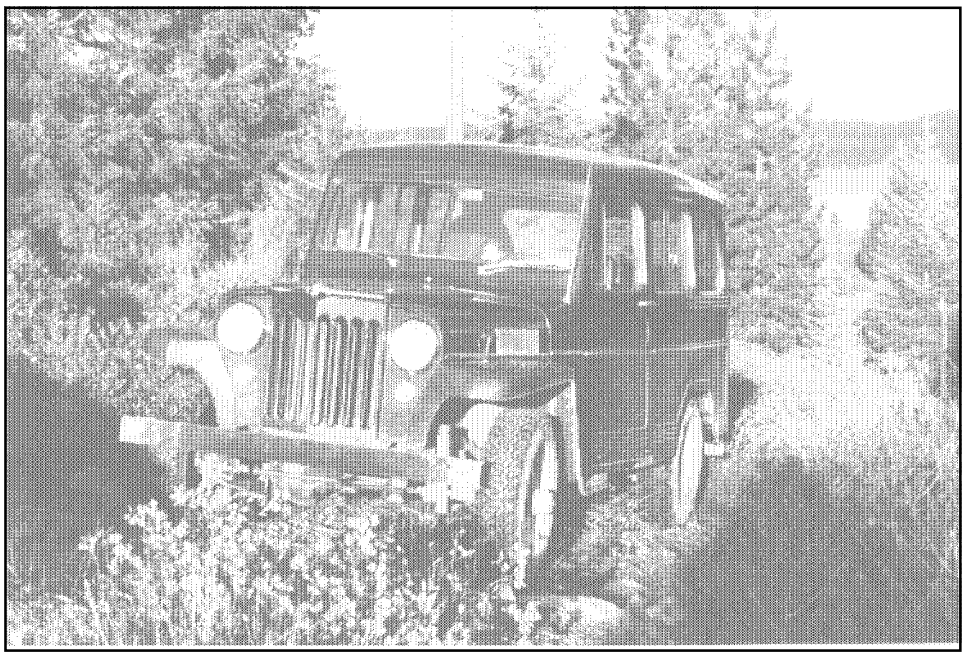
Now I could have walked down to the neighbors a half mile away and asked for a jump start but that would have been a humiliating defeat. Figured I could push start the Jeep, only problem being that it was already parked in a low spot. With the aid of a hand winch and a nearby stump, I laboriously inched the Jeep 20 feet or so up a slope, then let it roll down, let out the clutch and... it didn't start. It took about 20 minutes for a repeat try with the same result. Needed a longer downgrade. The battery wasn't completely dead but wasn't lively enough to make a strong spark, I figured.

The alternative plan was to push the Jeep about 50 yards up a slight grade, beyond which there was a long hill to roll down. Ever push a car uphill? It isn't easy. I could only do it by grabbing and turning a front wheel, which had lots of fender clearance and knobby tread to grab on to. After considerable effort I got rolling downhill and the engine started. For those not familiar with this procedure, DON'T use the lowest gear when you try to start the engine this way. Think about it, the mechanical advantage of the transmission is working in reverse order. Now if I could just remember my Pelton wheel...

Soon after that experience I obtained separate batteries for my evolving alternate energy system.

Access

Clive Ellis, 2039 Manzanita St., Klamath Falls, OR 97601.



Above: '56 Jeep hull down in the mud. Photo by Clive Ellis

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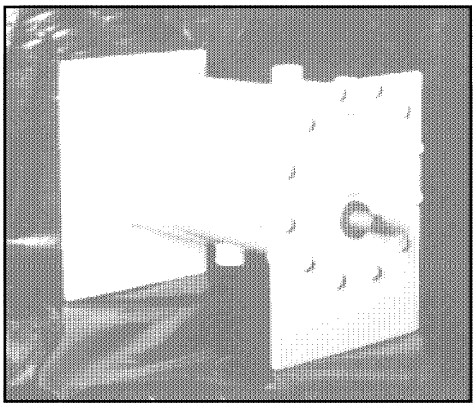

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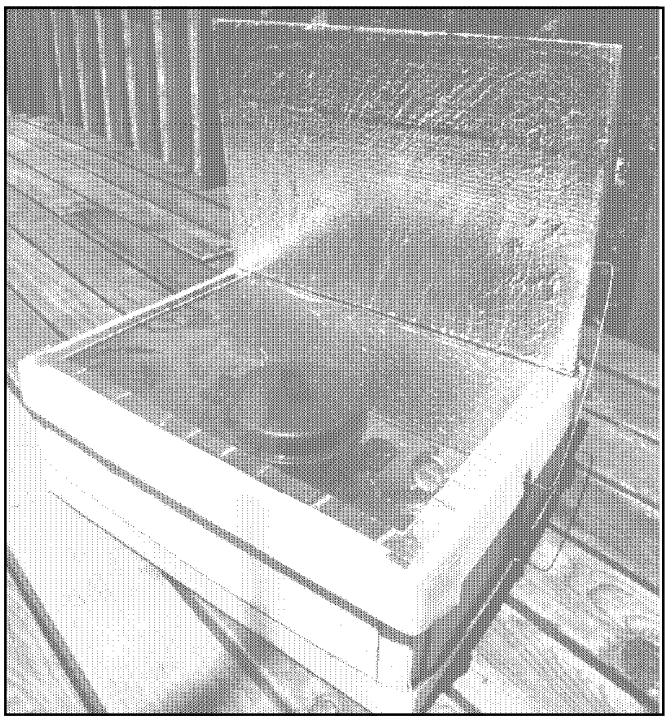
Things that Work!
The Solar Gourmet Solar Cooker Kit

Things that Work!
tested by Home Power

Testing conducted by Kathleen Jarschke-Schultze

I have cooked many solar meals in several different solar cookers. All of them have been of a multiple reflector design. I was very curious about single reflector box cookers. When Basic Solar sent us their solar cooker kit I was eager to test it.



Packaging and Documentation

The unit arrived in good shape unassembled and folded into a neat package. I took all the parts out and separated them. Then I read the documentation. The manual tells the assembler to remember how the oven is folded so they can refold it easily. I suggest adding an exploded view of the folded oven to the instructions.

The instructions say the estimated time for assembly is one hour. I started a timer when I began. I did not hurry or try to save time, I just worked steadily. It took me 1 hour & 13 minutes to assemble. The instructions are easy to understand and contain diagrams of set up and cooking basics. My unit did not have a guide hole marked on its side, so I guessed it would go in the middle. This worked fine. Here are a few instructions I would add. If you spill the glue on the foil it can be wiped off with a damp cloth. If you pull the paper backing off of the heat resistant tape pieces all at once, then it will curl up and stick to itself.

The Solar Gourmet

The cooker itself is smooth clean cardboard cut and folded into an ingenious, well insulated oven box. The inside oven dimensions are 22" x 16" x 6 1/2". The window on the top of the cooker lid is a thermal pane of two sheets of UV-resistant mylar. The one reflector folds down over the window to protect it when moving or storing. All the pieces fit together well. That also means that when you pick it up you must support the bottom or the pieces will slide apart again. If this were my oven I would just glue the pieces in place for stability. The size of the oven completely assembled is 9" x 19" x 25". It weighs only 5.25 lbs. This makes it very easy to move about. In the folded storage mode the unit is only 3" tall,

Solar Gourmet Performance

	Outside Temp.	*Oven Temp.*	*Comments*
6 June 91			miracle maid pot & lid
10:10 AM	67.3°F.	110°F.	4 C rice & 6 C water
11:00 AM	70.0°F.	225°F.	clear sky
12:00 PM	72.0°F.	200°F.	hazy sky
1:00 PM	78.3°F.	125°F.	lid fell, adjusted oven
2:00 PM	80.6°F.	250°F.	rice perfectly done
1 July 91			visionware casserole
12:00 PM	84.6°F.	100°F.	walnut-apple cobbler
1:00 PM	86.9°F.	215°F.	breeze, cobbler rising
2:00 PM	89.2°F.	230°F.	cobbler bubbling
3:00 AM	90.7°F.	250°F.	cobbler done
2 July 91			visionware casserole
10:30 AM	85.5°F.	150°F.	chicken & veggies
11:30 AM	90.7°F.	200°F.	adjusted oven
12:30 PM	93.6°F.	215°F.	still cooking
1:30 PM	96.3°F.	225°F.	adjusted oven
2:30 PM	96.8°F.	250°F.	bubbling & browning
3:30 PM	97.9°F.	250°F.	done well

making it very easy to store.

We live in a canyon, so I was worried the wind would blow the lid-reflector off. I attached Velcro to the sides to stabilize the reflector. The weight of the pots holds the whole oven down. The reflector's positioning scheme could be made more durable. I believe this could be accomplished by placing a strip of heat resistant tape along the edge of the reflector on both sides.

Performance
I cooked a variety of foods in the Solar Gourmet. It cooked rice very well and effortlessly. The cobbler browned nicely. The only time I adjusted the oven and preheated it was when I had a very large meal cooking. It included a whole chicken, six whole potatoes, two thick sliced carrots, chopped celery and shallots and a cup of apple wine in a large Visionware® casserole. It came out very succulent and delicious with enough liquid to make gravy. When that meal had finished cooking at 3:30 PM, I just lowered the reflector over the window to keep it warm. We ate at 6:00 PM and dinner was still warm.

This oven does not seem to get as hot as my other solar cookers, but it has no problem cooking food of all sorts.

Conclusion
This is a good solar cooker. When you spend $39.95 for the Solar Gourmet, you get an easy to assemble solar cooker that will work the day you get it. It is a cardboard oven, so it must be protected from rain. It is light and portable. It's cooking area is flat and stable. It is easy to slide around to focus to the sun. It doesn't get as hot as a multi-reflector oven. When I was cooking the rice, a breeze caused the reflector to fall over the window. The temperature had dropped to 125° F. I adjusted the reflector and the oven. The temperature rose to 150° F in 4 min., 200° F. in 10 min., and to 225° F in 20 min.

When I called Basic Solar with my suggestions they were interested in the feedback. They say they will be incorporating the ideas into future kits. Basic Solar also provides access to non-profit solar box cooker organizations.

Access
Basic Solar, Harvard Square Suite 67, 1430 Mass. Ave., Cambridge, MA 02138 USA FAX: 206-525-1418
Solar Box Cookers International, 1724 Eleventh St., Sacramento, CA 95814 USA 619-444-6616 FAX: 619-447-8689 Econet:sbci
Solar Box Cookers Northwest, 7036 18th Ave NE, Seattle, WA 98115 USA Voice/FAX: 206-525-1418 Econet:sbcn Telex:1502097451

SCI
ad
patch
on
paste-up

Solar Car Corp.
add HP designator

Reducing AC Magnetic Fields

Bob–O Schultze and Richard Perez

Last issue we discussed measuring the ac magnetic fields in our home power systems. This issue we offer some solutions to the problem. These solutions are easy to do, mostly inexpensive and dramatically reduce the magnetic fields radiated by the ac wiring in our walls.

The Test Setup

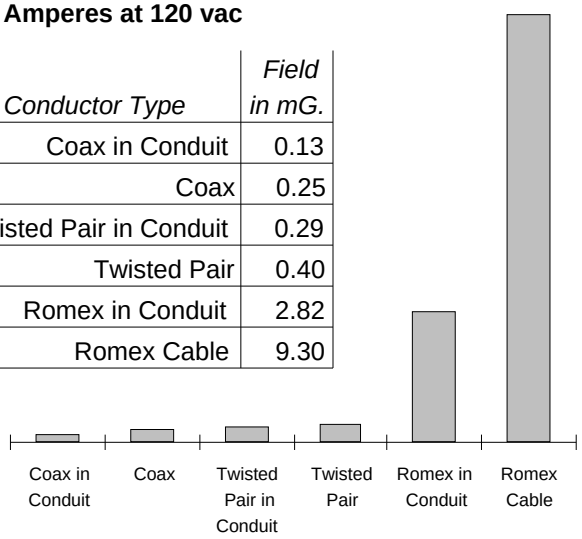
We fed a 300 Watt incandescent heat lamp with an inverter. We wired the lamp with a variety of wiring techniques. First we used regular Romex cable with parallel conductors. Then we inserted the Romex into a 1/2 inch EMT conduit. Then we repeated the procedures with twisted pair wiring and coax, each with and without conduit. At each experimental stage we measured the ac magnetic field radiated by the wire with the milliGauss meter described in HP23. We built a cardboard jig to hold the probe exactly 1 inch from the conductors under test. This insured that all measurements were taken at the same distance from the conductor. Here's what we found out.

Ac magnetic field reduction

The use of the alternative wiring techniques shown on the table can radically reduce the presence of ac magnetic fields. Twisted pair wiring inside of conduit offers the most cost-effective solution. Coax is not only expensive but also difficult to work with. Twisted pair wiring is easily accomplished by purchasing single conductor wire and twisting them together using a drill and vise. Even without the use of conduit. twisting the conductors together (about four to six twists per foot) reduces the magnetic field by over twenty times.

AC Magnetic Fields
for different conductors
2.5 Amperes at 120 vac

Conductor Type	*Field in mG.*
Coax in Conduit	0.13
Coax	0.25
Twisted Pair in Conduit	0.29
Twisted Pair	0.40
Romex in Conduit	2.82
Romex Cable	9.30



Errata

The Radio Shack part number for the relay coil used in the Mag Field meter's probe in HP23 was in error. The correct part number is RS# 275-233.

Access

Bob–O Schultze, Electron Connection, POB 203, Hornbrook, CA 96044 • 916-475-3401.

Richard Perez, C/O Home Power, POB 130, Hornbrook, CA 96044 • 916-475-3179.

PRODUCT UPDATE
45/60/90 and 120 Amp Charge Controllers

Heliotrope General's constant quest for the best in products at competitive prices, has produced the CC-60C / CC-120C PWM charge controls. The major change in the "C" suffix charge controllers is standardization of the LCD digital readout consisting of "Array Voltage", Battery Voltage", and "Charging Current". All features available previously on the "B" models are still incorporated in the new "C" models.

"Knowing your systems performance status is vital for the efficient use of available energy". What better way to check performance than with an incorporated digital display?

Sandia National Labs latest test results (June 11, 1991) indicate Pulse Width Modulation (PWM) design superior in performance vs. other commercially available designs.

All Heliotrope General charge controls incorporate the superior PWM control strategy for accurate, reliable, proven performance, resulting in the highest battery state of charge in the industry. The high battery state of charge is accomplished with low battery water consumption.

For more information or copies of test data contact:

Barry W. Brunye' or Glen Parker
Heliotrope General
3733 Kenora Drive
Spring Valley, CA 91977
800-552-8838

Thermosyphon Heat Exchanger

Willson Bloch

Prior to the advent of thermosyphoning heat exchangers, designers had two choices when installing a closed-loop solar hot water system. One: they could use a storage tank with an internal or jacketed heat exchanger, or two: they could use an external tube-in-shell heat exchanger with a pump.

Internal Heat Exchanger

Solution one seemed like the best way, but it posed two problems. Heat exchanger equipped tanks were very expensive and when tank replacement became necessary, the heat exchanger went too. Secondly, because of its internal location, it was impossible to descale the mineral buildup from the heat exchanger. This rendered it less and less effective as the mineral coating grew thicker and thicker while often accelerating the deterioration of the tank itself.

External Tube-in-shell

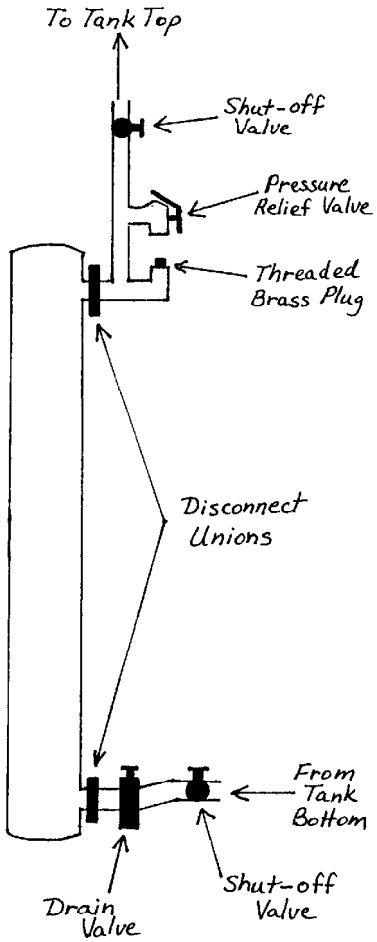
Solution two was an external tube-in-shell heat exchanger with applied pump to extract the heat from the solar fluid to return it to the storage tank. This solved both problems of the internal heat exchanger but only by adding a pump with its parasitic electrical consumption. Also, the pumped heat exchanger didn't work very efficiently because the pump always pumped at the same speed regardless of the available solar radiation and corresponding solar fluid temperature.

Thermosyphon

In 1984, Noranda Corporation released the first thermosyphoning, external heat exchanger. The design was good, but the materials used in its construction were below standard despite the International Association of Plumbing and Mechanical Officials, (IAPMO), stamp of approval. Note: Drain, waste, and vent pipe, (DWV), and test caps were approved for use in household, (150 psi), situations. Also, the set of installation instructions that were included with the heat exchanger showed that Noranda hadn't really researched their product well.

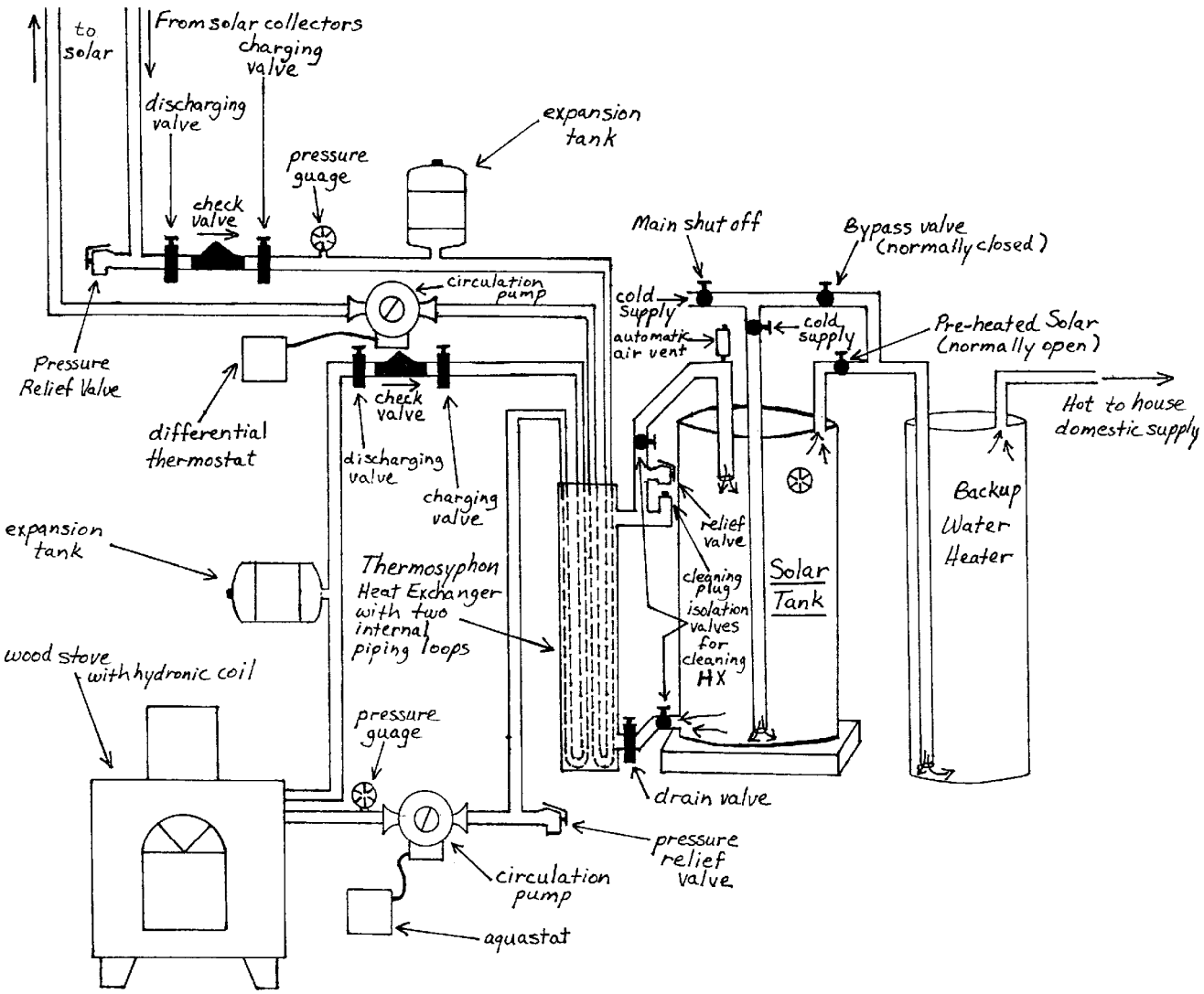
I purchased several of the Noranda exchangers and through experimentation, discovered the method of installation that produced optimum results. I especially liked the way the exchanger heated the storage tank from the top down rather than gradually bringing the whole tank up to maximum solar temperature by the day's end. The thermosyphoning method meant that hot water would be available to the user much earlier in the day. Days of marginal solar radiation would produce some useable hot water in the upper portion of the tank rather than the whole tank being lukewarm. Also, the thermosyphoning action works proportionally with the amount of available solar radiation.

With its vertical mounting position alongside the storage tank, cleaning the exchanger is a breeze when installed with two shut off valves, a boiler drain, and fill plug. A simple 30 minute task can clean off mineral build up and return the exchanger to like-new condition. This means that a properly built thermosyphon heat exchanger will last a lifetime with only miniscule care.



Homebrew

Noranda never did upgrade their thermosyphoning heat exchanger and when the solar tax credits died, they got completely out of the heat exchanger business. Another company in Florida came out with another type of thermosyphoning external heat exchanger that served as an elevating pad for the tank, but its accessibility to



cleaning didn't please me. I decided at that time to build an exchanger similar to the Noranda design but with improvements in size, efficiency, and especially in pressure-durability. It is now commercially available, and some typical installation diagrams as well as cleaning procedures follow:

Cleaning the Heat Exchanger (HX)

1. Close, (clockwise), the upper and lower shutoff valves.
2. Open drain valve at bottom and remove threaded brass plug at top to drain the water from the HX.
3. Close drain valve and fill the HX with one gallon of white vinegar. Top off with water so that HX is completely filled.
4. Reinstall the brass plug.
5. Turn on the solar system so that the solar fluid heats up the HX till it is hot to the touch, then turn the solar system off and let the HX sit for 20 to 25 minutes, (longer if the HX is really scaled-up).
6. Open the drain valve and remove the brass plug to drain out the vinegar and water solution, and then replace the brass plug.
7. Leave the drain valve open and open the upper shut-off valve to flush out any remaining vinegar and water solution, then close the drain valve.
8. Open the lower shut-off valve and you are finished. You might double-check that both shut-off valves are open to be sure that the HX can begin thermosyphoning otherwise your pressure relief valve will blow off.

Access

Willson Bloch, Sunburst Horizons Co., 22580 Hwy 184, Dolores, CO 81323-9111 • tele: 303-882- 4558.

Tech Notes:

Inverter Wiring Protection

Todd Cory

Inverter primary wiring has always been difficult for me to justify protecting. Due mainly to the high costs of UL approved safety interruption devices, and low probability of a short in the circuit. I recently researched the following fuse, with the help of my friend, Bill Munholand, at Mt. Shasta Electric. I now include this on all wiring jobs involving battery driven inverter systems that I do.

Ordering Info

Cross Reference: Reliance/Brush #RFA, or Bussman #KAA, or Gould/Shawnut #A 13X

The length of a 300 amp fuse is 2 5/8" x 1" wide. Follow the fuse catalog symbol with the desired amperage, for example a Trace 2012 would require a 300 amp fuse. So, if ordering a Buss fuse it would be a KAA-300. Available amperage ratings vary from 1 to 2,000 amps, UL approved for up to 130 VDC, with a DC interruption rating of 50,000 amps. The fuse, and Buss #3575 fuse block are rather inexpensive, considering the alternatives. A KAA-300 goes for around $35.00 with $20.00 for the connection/mounting block.

The Acid Test

The insertion loss is quite acceptable. Testing was done at a neighbor's house, with their Trace 2012, driven by 6 Trojan L-16s.

I chose nice, heavy resistive loads for this, and turned on their 1000 watt iron and 900 watt toaster. I measured the voltage drop across their 3' of 1/0 copper inverter primary wire with the previously mentioned fuse installed in line. The voltage drop with some 150 amps flowing was a meager 121.3 mV as measured with my Fluke D 800 digital meter.

Conclusion

As the N.E.C. requires protection of all circuits, this fuse makes compliance with regulations and incorporation of safe wiring of remote/home power systems not only easy but, inexpensive too.

Thanks to Bill Munholand for his help in tracking down this fuse and to Gary and Terri Orwig for the use of their system for testing procedures.

Access

Bill Munholand, Mt. Shasta Electric, 110 W Castle St., Mt. Shasta, CA 96067 • 916-926-3842

Todd Cory, Bald Mountain Solar, POB 313, Big Bend, CA 96011 • 916-337-6317

Carlson Communications Camera Ready

Tech Notes:

Gas Appliances

Jim Lambesis

Recently I have come across some important safety information concerning the use of gas refrigerators. Since many alternate energy folks use gas refrigerators, the possible hazards associated with these units should be known. Below is a warning quoted directly from a poster distributed by Servel.

"The U.S. Consumer Product Safety Commission (CPSC) says that old model Servel refrigerators have caused at least 14 deaths nationwide as the result of carbon monoxide poisoning. These refrigerators continue to be used in hunting cabins, vacation cottages and remote areas of the nation where there is no electricity, or where gas is a preferred energy source. To protect yourself and your family from potential hazard, stop using your old Servel gas refrigerator immediately.

Over a period of time, especially if the refrigerator has not been used recently, the gas burner can be fouled by dust, dirt, rust, spider webs or other obstructions. This can cause improper combustion of the fuel, leading to the production of carbon monoxide, a colorless, odorless and deadly gas. Any gas refrigerator with an improperly adjusted or partially plugged burner can produce enough carbon monoxide to kill the occupants of a cottage or house in one night. Symptoms of carbon monoxide poisoning include nausea, headaches and dizziness.

RECEIVE CASH FOR YOUR SERVEL REFRIGERATOR.

The CPSC has arranged for you to receive $100.00 in exchange for your old Servel refrigerator. Call the Servel Hotline toll-free at 1-800-782-7431. Operators are standing by 24 hours a day to answer your questions and make arrangements for a qualified propane dealer to remove the refrigerator from your home or cottage at no cost to you.

REPRESENTATIVES ARE STANDING BY.

If you have a Servel gas fueled refrigerator, call the toll-free number, 1-800-782-7431, or write to: Servel Rebate, P.O. BOX 14874,Cleveland, OH, 44114."

I would like to expand on this notice and briefly talk about carbon monoxide and the proper use of gas appliances.

Carbon Monoxide

The above mentioned of the dangers of carbon monoxide poisoning are easily misunderstood. Carbon monoxide is a colorless, odorless and non-irritating gas. It is formed during incomplete combustion of carbon or carbon containing substances.

Carbon monoxide is an insidious poison. It produces only mild symptoms of headache and nausea. It can cause unconsciousness before the person can prevent it or knows what is happening. Irregular breathing, ringing in the ears, seeing spots and dizziness are some of the other symptoms. Only 1000 parts per million of carbon monoxide or 0.10 percent in air can be fatal. 4000 parts per million (0.4 % in air) are fatal in exposures of less than an hour. Sometimes the above symptoms can be misdiagnosed as the flu. Continued low exposure over a period of time will cause an accumulation of carbon monoxide poisoning. Cases do occur where a person would stay home because of illness only to become progressively worse because of the additional exposure time to low levels of carbon monoxide.

First Aid

If a person shows evidence of carbon monoxide poisoning, immediately get that person into fresh air. Next lay the person down and give artificial respiration if necessary. Call the fire department and doctor for oxygen and treat for shock.

Gas Appliances

Many alternate energy folks are quite creative with gas appliances. A better understanding of gas equipment is called for. As with any tool, improper use and operation will cause a safety hazard.

Sometimes a person will service gas appliances themselves thinking that it is a simple device that can be easily fixed and checked. A little knowledge of gas appliances can be very dangerous when someone tries to service them or worse yet, perform modifications for greater efficiency. Gas Appliances are complex devices that appear to be very simple. Commonly, the operating principles of a gas appliance are not completely understood. Consult with a gas appliance professional or the appliance's manufacturer before servicing or adjusting gas appliances.

There are specific safety devices in gas appliances that must not be modified. I have seen some home-made devices and ill-qualified repairs that are dangerous. Modifications of gas equipment should be approved by the manufacturer and meet the American Gas Association testing lab standards.

If a hazardous condition is suspected with a gas appliance, the local gas utility in most cases, will come out free of charge for a safety check. Gas appliances should be cleaned, adjusted and safety checked at least yearly.

Proper Venting
The proper venting of gas appliances is very important. If a gas appliance is not vented properly, carbon monoxide can be easily produced. I have seen makeshift venting arrangements that are very dangerous and have refused to stay at that household. The flue system must vent to the outside in a proper manner and must meet code. Flue pipes should not vent outside through a wall unless it is designed to do so by the manufacturer.

A simple test can be utilized to determine if a gas appliance is venting properly. It is performed by placing a lighted match at the draft diverter when the appliance has been operating for a few minutes. If the draft diverter is spilling products of combustion, the match will blow out or the flame will be pushed downward and away from the draft diverter. This indicates a serious venting problem that must be corrected immediately. This test is not intended as a substitute for a complete chimney inspection, but will identify an immediate venting problem. Knowing the condition, proper design and operating characteristics of a chimney is always required for utilization of gas equipment.

Wood Stoves And Chimneys
Adding a wood stove to an existing flue pipe that is connected to a gas appliance is against the National Fuel Gas Code and other regulatory agencies. A wood stove or fireplace must have its own flue pipe.

All flue pipes must be clean and in good repair without any restrictions. Chimneys must be of the proper height in relation to the roof of the house. If a liner is not present or the existing one is broken or over sized for the application, it must be repaired, relined or replaced.

Medium Efficiency Gas Equipment
In most cases, medium efficiency gas equipment requires the existing chimney to be relined with a stainless steel liner to prevent excess condensation. Excess condensation will lead to the premature deterioration of a chimney. Check with the local gas utility and manufacture when medium efficiency gas equipment is used.

Flame Characteristics
The flame characteristics of a gas appliance is very important. It must have a blue color without lifting off the burners and be of a size that does not impinge on the heat exchanger. A yellow flame indicates a serious problem that requires immediate attention because it will cause the formation of black soot in the gas appliance and chimney. Black soot must be cleaned out before the repaired appliance is put back in operation. Lines of soot on the exterior surfaces of an appliance is a clue that indicates a serious problem. All of the above conditions usually prevent the completion of the combustion process and will produce carbon monoxide.

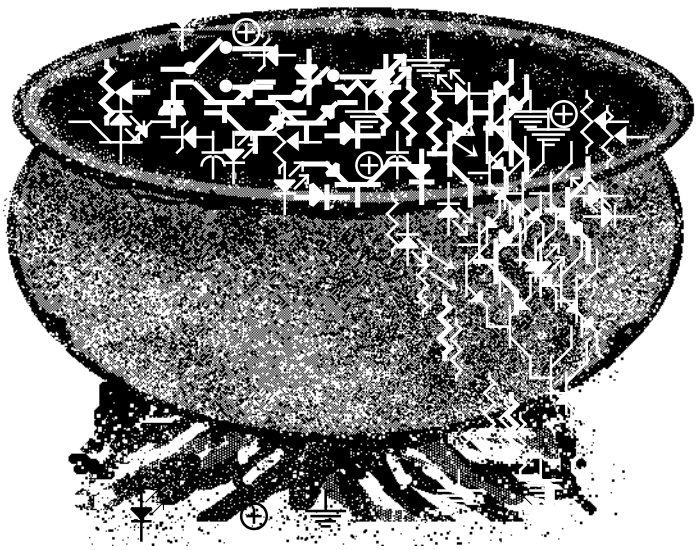
Conclusion
The maintenance, repair, and installation of gas appliances are rather complex and should be performed by a professional or under the direction of a professional. If you do it yourself, then have it checked by a professional before the appliance is put in operation. At least once a year every gas appliance and chimney must be inspected, cleaned and adjusted if necessary. Any modification must have approval from the manufacturer and the American Gas Association. If you have a Servel gas refrigerator, call the hot line.

Access
Jim Lambesis, Middle Fork Engineering, 621 Dalton, Northbrook, IL 60062

Fowler
Solar
Electric

camera ready

Homebrew



12 And 24 Volts in a Portable Package

Dan Lepinski

Ever need 24 volts when you only had 12 volts available? Or maybe you wanted 12 volts when the system ran 24 volts? Here is a handy little circuit that can provide portable power of either voltage at the flip of a switch. Better yet, you can recharge the batteries from either voltage level as well!

The Basic Circuit

In its simplest form, only two batteries, one switch, and a fuse are needed. The switch must be rated to carry the current that you will draw from the batteries. I never needed over 4 amps at either voltage level so the switch I used (and shown in the parts list) is rated for 6 amps. You may substitute a heavier switch. The batteries should have an ampere-hour rating suitable for your anticipated load. Also, the batteries themselves should be of identical capacity. Rate the fuse to pass approximately 20% more current than will be drawn by the heaviest load.

Construction

There is nothing critical about any of the components used in this little battery pack. A single plug or connector may be used both for power output as well as charging, although both should not be done at the same time. The wire used to connect the batteries to the outside world should be capable of carrying the maximum anticipated current without undue loss.

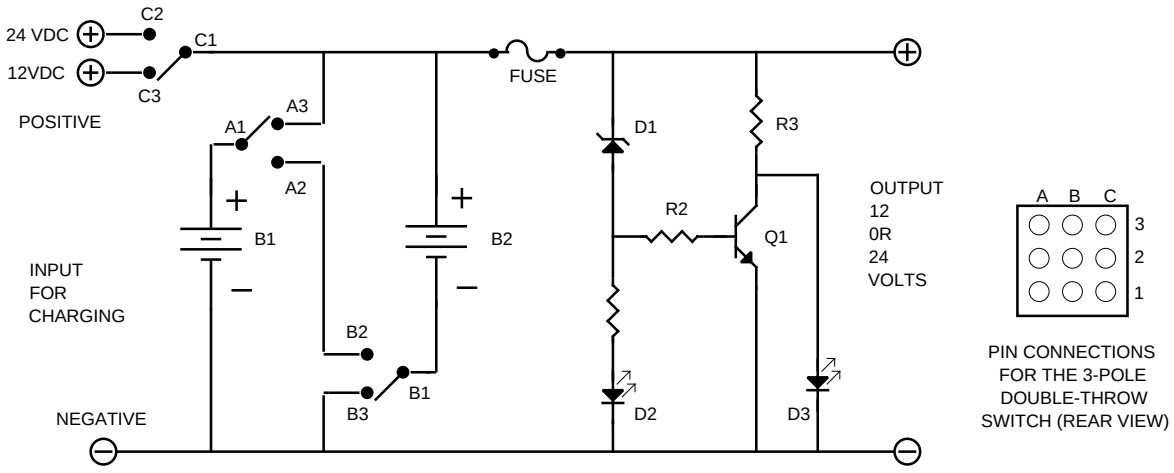
If you would like to add a visual indicator of the output voltage level, an optional circuit to perform that function is shown. For minimum current drain from the batteries, this circuit may be omitted. If you would like the best of both worlds, you could use a "center-off" version of the switch. This will allow use of the visual circuit and also provides a means of disconnecting everything.

Battery Charging

To recharge the batteries, select the voltage that matches your charger's output and connect the charger to the battery pack. You may use the output connector or install a separate one just for charging. By wiring the circuit with the 3-pole switch (as shown), you will only be able to charge the batteries with the voltage selection switch in the position that matches your charger voltage.

Caveat

If you cannot locate a 3-pole double-throw switch, a



SWITCH SHOWN IN 12 VOLT OPERATING POSITION.
D2 LED ON FOR 24 VOLT OPERATION. D3 LED ON FOR 12 VOLT OPERATION.

double-pole double-throw switch may be used IF certain precautions are observed; you MUST place the voltage selector switch in the proper position BEFORE connecting the charger. Exciting times can result if you forget to perform this simple step. A fundamental warning is in order here: Exercise care when using or charging this battery pack. Expensive repairs or injury can result if you get careless.

Final Note
Tri-Tek has a limited supply of surplus 6 volt 10 AH sealed lead acid cells available for $6.95 each or $24.95 in groups of 4. These are ideal for a portable power supply of this type.

Basic Parts List:
Two 12 Volt or four 6 volt batteries (sized per your requirements) 3-pole Double-throw switch (optional 2 pole may be used) One fuse holder One fuse (appropriate for your load)

Basic Power Supply Parts & Suppliers:
3-pole, 6 Amp double-throw switch Tri-Tek, Inc.
12 Volt batteries sized as needed Tri-Tek or HP ads
Double-pole double throw 6 Amp switch Radio Shack 275-652 (optional)
Double-pole double throw 10 Amp switch Radio Shack 275-1533 (optional)
Fuse holder & fuse Radio Shack
Surplus Panasonic 6V, 10 AH sealed lead-acid battery from Tri-Tek, Inc. (while supply lasts)

Miscellaneous hardware as needed
Visual Voltage Level Indicator (Optional):
D1 18 Volt, 1 Watt Zener diode 1N4746A
D2 Red LED (or color of your choice)
D3 Yellow LED (or color of your choice)
Q1 2N2222A or similar NPN switching transistor
R1, R2 1.2K ohm, 1/4 watt resistor
R3 820 ohm, 1/4 watt resistor

Access:
Author: Dan Lepinski, 4631 W. Marlette Ave,, Glendale, AZ 85301

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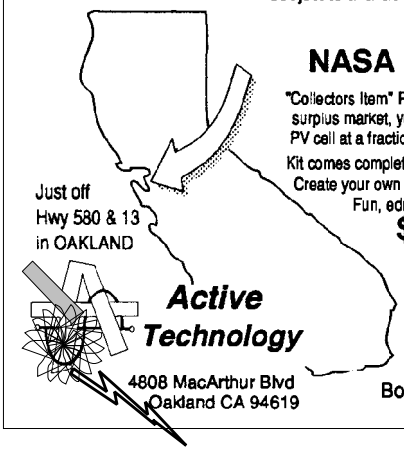

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Kit comes complete with 3 cells & 3 ultra-efficient motors. Create your own "Gizmo's". You provide the ingenuity. Fun, educational and decorative too!

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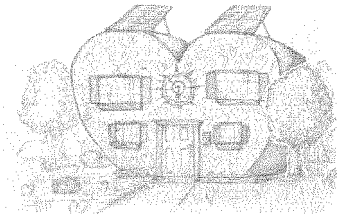
Energy Systems & Design
POB 1557, Sussex, N.B. Canada E0E 1P0
506-433-3151

Home & Heart



Kathleen Jarschke-Schultze

When I started my rural off-grid lifestyle the closest supermarket was two and a half hours away, so I was introduced to a new way of buying food. By joining the Salmon River Food Co-op I not only saved money but began to use foods that were healthier for my family.

Green Noodles and Brown Rice

I had never really eaten brown rice before but it was the only kind Bob-O had. I had to learn how to cook it. It wasn't at all like the Minute Rice I was used to. Didn't taste the same either. I tried and tried to cook the green vegetable noodles but they always came out like mush. I always liked spaghetti on the second day after it was made but this stuff was a no-go.

After these disappointing failures I was hesitant to try using 'health foods' in my daily cooking. Then a sympathetic River woman introduced me to the Salmon River Food Co-op. This group orders bulk health foods and organic produce from Mountain People's Warehouse, a supplier of same to the western states. They deliver to California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming, with container shipments to Hawaii and Alaska.

To Boldly Go

These people really appeal to me. Their logo is an MPW rocket powered delivery truck flying over the mountains and valleys with the motto; "To Boldly Go Where No Distributor Has Gone Before". Their extensive delivery network reaches many western rural areas, but is not limited to them. My sister has started a food club in San Bernadino, while my sister-in-law started one in the Bay Area.

The catalog costs $1.50 and is well worth the price. Inside, the catalog is informative, comprehensive and totally fascinating. The first few pages explain their policies and the areas of delivery. The products are listed by type in the Table of Contents and by manufacturer in the Brand Name Index. The latest catalog is 106 pages full of great bargains. A new catalog comes out every three months and MPW is always stocking more lines of organic food and eco-safe products. Once you get them on the mailing list all the members of the Co-op receive a monthly sales booklet with the sale items for that month. There is usually a newsletter with it, called the Eater's Digest, that gives information about new product lines, availability of current produce and introduces new employees of MPW.

Cases and Co-ops

When we moved from the River I found it very difficult, and expensive, to continue to purchase the foods I had become accustomed to using. I talked to my neighbors and a couple of people in Hornbrook and formed the Camp Creek Co-op. We have seven to nine families that order each time.

MPW supplies many health food stores and large Co-ops, so the food comes in large amounts. You usually have to order a case of cans, bottles, or boxes. Bulk foods (grains, dried fruit, pasta, beans, etc.) are sold in 50 lb., 25 lb., 10 lb., and 5 lb. lots. There are some things in smaller portions so read the catalog carefully.

We have worked it out so that we all order what we want then get together to decide if any of the rest of us want to split cases or portions of the food. Like six lbs. of Mozzarella is a bit much for our family, but I can usually split off a lb. or two to a couple other members. This works well if you want to try some thing but aren't sure you like it enough to get a whole case.

Another way to check out products before you buy too much is to go to your local health food store and buy one or two of the item and try it out on the family. If they like it you can get it a lot cheaper through MPW.

Basmati and Sesame

I never realized that eating healthy could be so much fun or taste so good. I'm afraid I never did learn how to cook green noodles but my friend, Sarah, turned me on to sesame noodles. They cook just like the ones I was used to but are a lot better for you. As for brown rice, I discovered Basmati brown rice. It has to be the best kind of rice. It is long grain, fragrant and really tasty. I found such a wide selection of products available that I can stock the cupboards full of staples just from the catalog. Health foods aren't what I thought they were and they don't cost as much either.

West and East

I am sure there must be other distributors who provide the service MPW does. When I called them to find out, one of their office workers had lived back East and knew of two distributors there. They are Stoew Mill and Cornucopia. We haven't been able to get access information on them, so I would like to hear from readers who order from either or both of them.

Vacuum Variety

Jorrie and Ken Ciotti, of the Holistic Institute of Montana, wrote to tell me about several vacuums they use regularly. They use: Central Vac for RVs, Shop-Vac Wet/Dry Model 610, HP Vacuflo, and Sears Model 116 with Power-Mate

Jorrie says, " The best carpet vacuum is the Sears with Power-Mate. The Power-Mate does an excellent job of getting carpets clean quickly. It uses 12 amps with the Power-Mate; 9 amps without it. The Power-Mate is a carpet attachment to the sweeper that can be removed so you can use all the other typical sweeper tools: floor brush, crevice tool, fabric brush, and dusting brush.

The HP Vacuflo is our house sweeper that runs off of the Trace 2012 with the T220 attachment. It uses 6 amps, 230 volts. We have oak wood floors and this is an excellent sweeper. We prefer central vacuums because the other vacuums bother my lungs. Something else that I like about this vacuum is that you don't have bags to purchase. When the canister gets full we recycle the contents in our Clivus Multrum.

We use the Shop-Vac for the shop and have had no problems with it. I don't like its lack of flexibility in the hose and the klunky attachments, but for the shop it's fine.

The Cental Vac for the RV does the carpet and floors nicely. The negative of this central vacuum is the cost of replacement bags.

Well, I hope this information helps a little. If the dust doesn't bother you, I recommend you get the Sears. The HP Vacuflo is my favorite and does a good job on carpets."

Access

Mountain People's Warehouse, 110 Springhill Dr., Grass Valley, CA 95945 Order desk: (916) 273-9531 • FAX: (916) 273-0326

HP Vacuflo, H-P Products, Inc., Louisville, OH 44641 • (216) 875-0326

Holistic Institute of Montana, Inc., 3000 Mill Rd., Niarada, MT 59852-0014

Author: Kathleen Jarschke-Schultze, C/O Home Power, POB 130, Hornbrook, CA 96044 • (916) 475-3401.

Due to the terminal illness of my husband Steve Taylor, owner of Steamco Solar Electric, I am unable to continue the business, and I am selling all inventory. I will, however, continue to manufacture the SPM2000 System Power Monitor. Lisa Taylor

Please, no COD's or VISA/MC. Cashiers checks or money orders only. Good Luck SEER '91. Wish we were there!

Steamco Solar Electric, 2700 Cantu Lane NW, Bremerton, WA 98312
206-830-4301 Phone lines will be open 1-4 PDT.

Solar RV Chargers; (2)I- $30 ea., II- $50, III- $150

Panels; (2)M65- $200 ea., (2)M55- $300 ea., (2)G25- $10 ea., G50- $30, (2) G100- $50 ea., SX10- $75, MSX30- $130, MSX40- $150

Batteries; (2)L16- $75 ea., (2)T105-$50 ea., Dynasty 1-13-B-$20

IBE Battery Charger, 125A, 24V, 220 line in-$500 OBO, Power Guard 27 Battery Box- $15, Power Guard 24 Battery Box-$10, Associated 6A Battery Charger- $15, Associated 10 amp Battery Charger- $25, Portable 12V Nickel Cadmium battery Charger-$20

Mayfair Bilge Pump- $15, Amazon Sub Inline Pump- $25, (4) DC Adapter- $2ea., (3) Electronic run portable- $10

Appliances from your car battery; (3) 12V plugs (single)- $2 ea., 12V extension cord- $5, DC Water Well Pressure Switch (cut-in 20psi, cut-out 40 psi)- $10, Mighty Mule Gate Opener- $300 OBO, 120AC 30 A X-fer-$30, Metal Cut-Out Boxes-(2) 6x6x4-$10ea., (2) 8x8x4-$15 ea., (2) 10x10x4-$20 ea.

Harris Hydro (15' min. head/150gpm flow) 8 nozzel 24V-$400 OBO

Statpower 600 Inverter- $250, Heart 600- $300

15W fluorescent- $15, (3)18W fluorescent-$15ea., Dual 8W-$15, (6)SW QH-$5ea., (4) 50W QH-$7ea., 22W Circle Line-$7

SBC 30-24 w/Divert- $75, SCI B3-12- $75, (4)NDR 30-2 no options- $75 ea., (2)SBC 3-12 w/divert & LBA- $75 ea., (3)LCB"T"- $20 ea., LCB 20-$100, SCI 2-24- $50,(2)M16-$20ea., M8M- $20, (2)SC-4- $10 ea., SCI Mark3-12V-$50, (2) Cruising Equip. AH Meter- $100 ea., Bobiers AH-Meter- $200 ea., Burkhardt 24V 50A- $100

ARCO 4 panel Mount- $80, (4) Flat Mount-$7ea., (3) Flat/tilt-$10

Murata M1600 Fax-Copier phone- $250, Mitsbisha Cellular Phone- $250, Columbia Computer- $200, (2) Epson Computer-$250 ea., (3) Walnut Showcases-$30 ea., Casio Cash Register- $50

Photron Power Guard P-PG-24- $100, (4) DC Voltmeter 22-23-$15 ea., (5) DC Ampmeters 0-5- $15 ea., (2) AC Voltmeters 50-150- $15 ea., (6) DC Ampmeters 0-30- $15 ea., (2) DC Ampmeter 0-60- $15, DC Voltmeter 10-16- $15, Bronze Pelton Wheel- $100, Solar Experiment Kit- $20, (4) Solar Speedboats-$15 ea.

The Complete Joy of Homebrewing

by Charlie Papazian

Reviewed by Tom Heinrichs

This is a different kind of homebrew than Home Power readers are used to. There are no FET's, rheostats, or puffs of capacitance mentioned in this book. We're talking barley, hops, and yeast in The Complete Joy of Homebrewing.

It costs the large American breweries a few cents to produce a bottle of beer. So where does the other forty-seven or so cents they charge for their product go? It goes to the Big Three in our consumer society: advertising, packaging, and distribution. Yes, you're paying to see washed up jocks push a product on TV, for containers the have to be melted down and remanufactured in order to be reused, and for gasoline to truck the stuff around.

But there is a better way: get a copy of Charlie Papazian's The Complete Joy of Home Brewing. This book will tell you everything you need to know about how to make your own beer that is approximately 947 times better than the stuff that passes as beer in American stores.

The plan goes like this: first, lay your hands on the necessary equipment. You need a five gallon bucket with a lid or a five gallon glass water bottle ($0-20), a rubber stopper and fermentation lock ($2), a hydrometer to measure the density of the beer ($4), three feet of plastic tubing to siphon the beer into bottles ($1), and a bottle capper ($4-12). You also need a big (3 or 4 gallon) kettle to boil the ingredients in. Second, you buy the ingredients (malted barley extract, hops, and beer yeast) for about twenty dollars. Third, you boil the stuff up, mix it with water in your big bucket, and add beer yeast. Put the lid with fermentation lock installed on it on the bucket. The fermentation lock is a one way valve. It lets the carbon dioxide out of the bucket as the yeast turns the barley sugars into alcohol and CO2, while keeping the air out.

Now you have to wait about a week for the yeast to do its thing. When the density of the beer (measured with your hydrometer) has stabilized, it's time to put it in bottles. You add 3/4 of a cup of corn sugar to the fermented beer and syphon it into bottles scrounged (reused!) from the recycling bin and cap them. The yeast uses this bit of sugar added at the end to make a little bit more alcohol and carbon dioxide. Wait another week for this carbon dioxide to form and be trapped in solution and carbonate the beer, then you're ready to drink your five gallons (50 bottles) of beer.

That's the quick rundown. You really need to lay your hands on The Complete Joy of Homebrewing for the whole story. Charlie Papazian will get you started with lists of ingredients, equipment, and instructions, and carry you just about as far as you want to go.

You might worry that a book with an information density as high as this one has might be dull--the Gray's Anatomy of beer, or something. Don't worry, The Complete Joy of Home Brewing is extremely well written and FUN to read. Papazian has a conversational writing style and provides information at several different levels: if you just want to know how to make the stuff, it's here. If you want the gory details of enzymatic actions, the fermentation process, or water chemistry, you'll find it in this book. You will be inspired to action by this book.

Once you get going, you will find your own beer tastes better because it's made from better ingredients and because it doesn't have the bad karma associated with the national ad industry, disposable containers, and energy spent moving what is mostly water all over the country. Your own beer is inexpensive ($20 for fifty bottles!) It's also more nutritious. But mostly, your own beer will taste better because you made it yourself. The Complete Joy of Homebrewing: you need a copy.

Access:
The Complete Joy of Homebrewing by Charlie Papazian is published by Avon Books, a division of The Hearst Corporation, 105 Madison Ave., New York, NY 10016. 1984, cost: $8.95 paperback (331p.), ISBN: 0-380-88369-4

Homebrewing supplies: look in the yellow pages under "Winemaking"; mail order: look in the classified adds in the back of Popular Science (or another hobbyist magazine) under "Winemaking"

Tom Heinrichs POB 84411, Fairbanks, AK 99708

H A P P E N I N G S

SEER '91 - WEST COAST ENERGY FAIR!

Solar Energy Expo & Rally, August 9, 10, 11 1991 in Willits, CA. Electric Vehicles Races, Demonstrations, Exhibitions. The Fair Grounds will be powered by Renewable Energy! The Home Power Crew will be there with bells on, stop by and say HI! Contact SEER'91, 239 S. Main St, Willits, CA 95490, 707-459-1256

Hands-On Solar Workshops

The Solar Technology Institute is offering the following summer Photovoltaic and Solar Energy Workshops.

Solar Energy for the Developing World, August 5-9 in Willits, CA. PV and solar thermal systems for improving life in developing countries.

Solar Technology for Rural Health Care, August 26-30, in Carbondale, CO. This workshop focuses on the technical skills needed for using solar technologies in developing countries. Included are: vaccine refrigeration, lighting, communication, and water pumping.

The cost of a one and/or two week program is $350. per week.

Solar Home Program 1991-1992. This series of How-To and Hands-On workshops is about designing and building state-of-the-art solar homes that are self-reliant, thermally efficient, healthy to live in, and environmentally conscious. Photovoltaic Design and Installation, Sept.9-20; Advanced Photovoltaics for Remote Home, Sept. 23-Oct. 3; Micro-Hydro Power Systems, Oct. 7-10; Solar Home Design and Construction, Oct. 14-24; Energy Efficient and Solar Remodeling, Oct. 28-Nov. 21; Passive Solar Design for Professionals, Jan. 13-23; Heating the Energy Efficient Home, Jan. 27-Feb. 20; Solar Building Skills, Mar. 2-May 1.

For detailed schedules and descriptions, costs, and scholarship information write, Solar Technology Institute, POB 1115, Carbondale, CO 81623-1115 or call Ken or Johnny at 303-963-0715.

Backwoods Solar Summer Workshops

Backwoods Solar will be holding several one day workshops on photovoltaic equipment and installation. Each workshop is limited to ten people. The cost is $40.00 per person, non-refundable pre-paid, which includes lunch and a text book ($30 per person if 2 people share the text book). The workshop will be held on the first Saturday of each month, September 7, 1991. For more information contact: Steve or Elizabeth Willey, Backwoods Solar Electric Systems, 8530-HP Rapid Lightning Creek Rd., Sandpoint, ID 83864, 208-263-4290

Hands-On Workshops in Maine

The Maine Solar Energy Association has started a series of hand-on solar workshops all around the state of Maine. The purpose of these practical, one day events is to de-mystify solar energy by showing the participants that it is practical today to use the sun to heat your home, make your hot water, furnish your electricity, and even cook your food and grow your vegetables out of season. In the past year we have had a very successful passive solar architecture workshop in Bangor, a solar greenhouse & sunspace workshop in Falmouth, and two photovoltaics workshops. The participants of the photovoltaic workshops actually constructed solar cell modules that they could take home for the cost of the parts. Some people made small solar battery chargers. Several participants assembled large 35 watt power modules.

In the coming year the expanded schedule of workshops will include; solar air heating, solar water heating, solar cookers and ovens, solar electric home, passive architecture, greenhouses and sun spaces, and the immensely popular photovoltaics workshop. The fee for each of these workshops is $25.00, which includes lunch.

For information on sites and dates contact Richard Komp, Maine Solar Energy Association, RFD Box 751, Addison, ME 04606, 207•497-2204

Electric Vehicle Club for Oregon

Lon Gillas of Pacific West Supply Co. in Amity, OR is organizing an electric vehicle club to promote electric transportation in the Pacific Northwest. Those interested in participating please contact Lon Gillas at P.O. Box 347, Amity, OR 97101, 503-835-1212.

Florida Solar Energy Center

The Photovoltaic System Design Workshop will be held at the Florida Solar Energy Center on, Oct. 22-24, 1991. This workshop will cover solar electric technology and the design of stand-alone and utility interactive PV systems aimed at engineers, government agencies, the solar industry and interested individuals. Cost $150, in-state, $300 out of state.

Energy Efficient FL Home Building: the newest ideas on designing & building an energy efficient home for home builders, inspectors & those thinking about building. 9/19 (Orlando) 1991. Cost $45.

For more information contact JoAnn Stirling, 300 State Rd 401, Cape Canaveral, FL 32920-4099 • 407-783-0300

NE Sustainable Energy Assoc.

September 23 & 24 1991, Energy Opportunities '91, Setting Energy Priorities for Commercial, Institutional and Industrial Buildings, Boxborough Host Hotel, Boxborough MA. Contact NESEA at 413-774-6051

October 26 & 26, 1991 - SOLAR AND ELECTRIC VEHICLE SYMPOSIUM will feature an extensive exhibit of prototype, pre-production EVs and components plus ongoing 30 minute workshops on the basics of EVs and presentations by specific car companies. The workshops will cover choosing the right components, photovoltaics, motors, batteries racing strategy, fund raising, team, electronics, conversions, composites wheels, design and more. The Symposium will be at the Sheraton Hotel, Boxborough, MA JUST OFF RT 495. Contact NESEA.

4th Annual American Tour de Sol, May 1992, solar and electric car championship. Contact NESEA at 413-774-6051

Minnesota Energy Council

The MN Energy Council will hold a number of conferences on new technology in energy and environmental management for housing, small buildings, small business and municipal buildings, aimed at professionals and business people. For more information contact: Roger Peterson, Minnesota Energy Council, Box 8222, St. Paul, MN 55108 • 612-378-2973

Solar World Congress

The Solar World Congress of the International Solar Energy Society will be held on August 17-24, 1991 in Denver, CO. Contact: American Solar Energy Society, 2400 Central Ave. Ste. B-1, Boulder, CO 80301 USA, 303-443-3130, FAX 303-443-3212.

Sunnyside Solar Seminars and Workshops

"Photovoltaic Home Electric Systems - Seminar and Workshop" is a one day program given at Sunnyside Solar, Inc. in Brattleboro, VT. It provides an introduction to independent solar electric systems and includes a hands-on workshop assembling a four module system. Each program is complete. The 1991 schedule is September 28 and October 19, each on a Saturday, 9 am to 4 pm. Advance registration, with a $35 deposit for each person, is required. The balance of $95. per person is due on the day of the workshop. Registration for each session is limited to the first eight deposits received. Included in the day's program is lunch, a packet of product information and related articles, and Joel Davidson's "The New Solar Electric Home".

For additional information and registration, contact Carol Levin, Sunnyside Solar, Inc., RDF4 Box 808, Green River Rd, Brattleboro, VT 05301, 802-257-1482

Fowler Solar Electric Solar Workshop

Fowler Solar Electric Inc. will be offering a solar electric workshop on Saturday, Sept. 28, 1991 in Worthington, MA.

This workshop is designed to teach potential PV homeowners to size, site, install, and live with a PV system.

Jeffrey and Lea Fowler will teach the workshop from 9:30 AM to 2:30 PM. From 2:30 PM to 4:30 PM there will be comprehensive product display, as well as a question session.

To register, please send $25 per person. If you are attending as a couple, you will pay only $35 for you and your spouse. Send your address and telephone number with your registration. We will respond by mail about 3 weeks before the workshop with a confirmation, instructions/directions, and complete information. Please bring your lunch.

Solar Energy in Sweden/Finland

A two week study tour (or one week option) of community scale renewable energy projects, research labs, and technology exhibition centers in Sweden and Finland, including solar, wind, and biomass. Both countries have major national initiatives to develop renewable energy. Opportunity to attend 1991 International Symposium on Energy and Environment in Espoo, Finland, August 25-28. Option to depart USA on August 22 for a one week tour to exhibition centers and symposium only. Full tour (two weeks) will include a visit to production plant for highly-insulated building components, and ferry across the Baltic Sea from Sweden to Finland with a seminar held on board. For more information on the Sweden/Finland tour or the 1992 Denmark/Germany tower contact the Minnesota Energy Council, POB 8222, St Paul, MN 55108, 612-378-2973

Environmental Protection Information Conference

EPIC, a leading edge exposition to demonstrate the latest technology, products, and services with the greatest promise for improving the environmental performance of the business community. EPIC is specifically intended to establish & strengthen business-to-business relationships

that promote cleaner, less toxic processes, technologies, and products in the marketplace. "EPIC presents a unique opportunity for the public and private sectors to showcase and examine the products, technologies, and services that are available to meet the environmental challenges facing the United States," said Senator Gore, EPIC's keynote speaker. The event will be held on Oct. 22, 1991 at the DC Armory in Washington, DC.

For more information contact Mark Flemister or Bob Frederick at EPIC 301-309-0700.

Rally in the San Luis Valley, Crestone Colorado

South Central Colorado Alternative Living Fair-August 10th thru 18th. Saturday and Sunday, August 10th and 11th-Sustainable Community Conference, Colorado College Seminar building at the Baca. August 15th thru 18th, Global Village Network Conference, Savitri Solar Dome in The Baca. Saturday, August 17th-2nd Annual Crestone-Baca Alternative Energy Fair, Crestone Park in The Baca, Solar Energy booths and Solar Cook-Off, Solar Powered Musical Entertainment. Sunday, August 18th-Solar Raffle and Tour of Sites. Fair is Free to the Public, camping available. For Conference costs and exhibitor information contact POB 54, Crestone, CO 81131, 719-256-4860. This is the time to rally 'round lifestyle alternatives at Crestone, Colorado, in the solar-active San Luis Valley, one hour north of Alamosa.

SunAmp Seminar

SunAmp Power Co. will hold two, 2 day PV seminars on September 20 & 21 and November 8 & 9, 1991. The seminars are designed for everyone from professionals to do-it-yourselfers. Topics will include introduction to PV hardware, demonstrations of systems, instrumentation , information access, system design and marketing.

Cost of each seminar is $175 ($125 for each additional person in the same party) and includes two lunches, refreshments, syllabus & classroom materials. A $50.00 deposit is required. For more information contact Steve at SunAmp Power Co., POB 6346, Scottsdale, AZ 85261-6346 • 602-833-1550 or TOLL FREE 1-800-677-6527.

Solar Electric Classes in Nevada

Solar Electric Classes for a max. of 4 students. Taught at remote Solar homesite. 2 days on the 4th weekend of Sept. Oct. Nov. Will build a small system. Class- $75.

For Info SASE to Solar Advantage, 4410 N. Rancho Dr. #148, Las Vegas, NV 89130 • 702-645-6571

Offline Workshop

A one day workshop, Designing Your Home PV Power System, will take place at Sun Mountain Research Center, Tollhouse, CA (near Fresno) on Sunday, Oct. 6, 1991 from 10am to 5pm for $35 or $45 for couples, the instructor is Don Loweburg. The day begins with a tour of the Sun Mountain PV system. A detailed discussion and design exercise will follow, with time allowed for individual projects. Bring a lunch, preregister no later than Sept. 23. You will be sent a map and registration confirmation, enrollment is limited. Register by sending check to; Offline, POB 231, North Fork, CA 93643 or for more info phone 209-877-7080

Permaculture Design Course in Florida

Dan Hemenway, editor and publisher of The International Permaculture Solutions Journal, will lead a full three week permaculture design course Oct. 19-Nov.9, 1991 in Orange Park, FL. The course will include sections on ecological design principles, design application of appropriate technologies and economic, social and legal considerations in permaculture design. Themes include energy, nutrient cycles, cultivated areas, potential catastrophes, water, buildings, urban design, alternative economics and bioregionalism. Students form teams and design the course site. For more information send SASE to Elfin Permaculture Institute, 7781 Lenox Ave., Jacksonville, FL 32221.

Earth Awareness Expo in Kansas City

On Oct. 11-13, Kansas City's Bartle Hall will host the area's first major annual exhibition dedicated to environmentalism and the marketplace. EAE'91 will combine informative, educational and motivational presentations with product and service demonstrations. which will include workshops, seminars, educational forums, eco-entrepreneurs, environmental action groups, government officials, practical presentations for home and office, energy- efficient alternative for transportation, industry, home use, and heating & cooling. Contact Earth Awareness Expo, 1423 Gentry, North Kansas City, MO 64116-3918 or call 1-800-442-XPOS, 816-472-2444

the Wizard Speaks…

Information

Here we all are involved in information transfer. Not the singular bit or byte transfers of knowledge only, but the larger pattern transfers of higher intelligence. If knowledge and technology are the operators of physical energy transformations, then information patterns are the operators of evolutionary and magical transmutations. In fact, even for physical energy transformations themselves, the correct informational patterns of the energies of higher intelligence must be in place in order to initiate new knowledge, facts, and technologies.

Knowledge and information are really quite different. Knowledge is basically a bit/byte oriented linear quantitative system serially processed. Information, on the other hand is a pattern oriented non-linear qualitative system whose pattern elements are parallel processed. Knowledge gets its working data from exact measurements of event parameters, while information uses as its data the patterns of relationships between event parameters. Knowledge is a rational system, its outputs are technological marvels and developed skills. Information is an intuitive system. Its outputs are miracles and magical talents.

Today we are in the middle of the transformation from knowledge systems to information systems. This can be seen in the evolution of computer systems from the classical Von Newman architectures to the new computer formats. One important result of this transformation will be the disappearance of the emphasis on meaning and the emergence of the wish for direct communication. This has already started with the attempt to develop non-verbal communication systems. This does not mean the absence of sound but the expansion of communication to all the senses including those not yet recognized by modern science.

As mind gives way to imagination, conflicts will be replaced by cooperative efforts and we may yet live to see PARADISE NOW! Let's all "Roll away the Stone".

Writing for Home Power Magazine

We specialize in hands-on, practical information about small-scale renewable energy production and use. We publish technical material in an easy to understand and use format.

Informational Content
Please include all the details! Be specific! Write from your direct experience- Home Power is hands-on! Please include full access data for equipment mentioned.

Article Style and Length
Home Power articles can be between 500 and 10,000 words. Length depends what you have to say. Say it in as few words as possible. Use simple declarative sentences- short and to the point. Use Sub-Headings to organize the information. Check out articles printed in HP to get the feeling of our style. Please send a double spaced, typewritten copy if possible. If not, please print.

Editing
We reserve the right to edit all articles for accuracy, length, and basic English. We get over three times more articles submitted than we can print. The most useful, specific and organized get printed first.

Photographs
We can work from a color or black & white photographic print. If your photo is for the color cover, then send a color transparency (color slide).

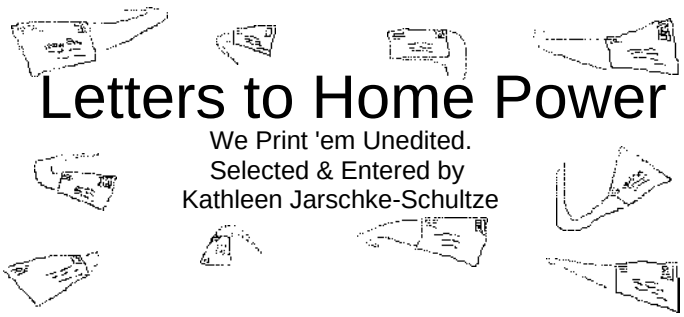
Line Art
We can work from your camera-ready art. We can also scan or redraw it. We can generate tables, charts, and graphs from your data.

Got a Computer?
Send your article on disk if possible. We use Mac computers. Please format all word processor files in ASCII "TEXT" format. We can read text files on 3.5" IBM disks. Format all graphics as PICT. Use 10 point Helvetica for all text embedded within graphics.

Want your material returned?
Please include a stamped, self-addressed, return envelope. Otherwise your material will not be returned.

Copyrighting
If you request it, we will copyright your work in your name. Otherwise we will copyright the information in Home Power's name.

Got any questions?
Give me a call at 916-475-3179. This saves everyone's time. *Richard Perez*



Letters to Home Power

We Print 'em Unedited.
Selected & Entered by
Kathleen Jarschke-Schultze

Tall Tower Tales

I'd like to add a few thoughts to Mick Sagrillo's useful article in issue 23. Old timers say that a three-legged towers are much more vulnerable to disaster than their less efficient four legged cousins. If anything happens to one leg of a tri-legger, down it comes. I saw one fall when a delivery truck backed into a leg. The same logic would tell you that guyed towers should have more than a minimum three cables, however elegant. Guy anchors invite damage. Many professional towers have six.

All towers should have lightning protection grounding systems that are separate from generator electrics and from concrete-set legs, poles, or guy anchors. I suggest a heavy cable plus deep ground rod at each earth contact point. Reason: a lightning bolt going down a leg or guy may blow off the concrete footings as it seeks ground. You know what comes next!

Mick's point about vibration is well taken. It is not possible to perfectly balance a wind machine for all conditions. I've seen well rigged Jakes slowly vibrate tower anchors right out of the ground (in the spring). One came to grief when a single rung of the tower ladder vibrated loose and was swept into the blades. Vibration may also cause the pole pad of a pole-and-guy setup to slowly sink (like your foot does when you pat it on wet sand at the beach) thus loosening all the guys. Ironically, nice tight guys will make the problem worse. That center pad has to be wide, deep and made with rebar. By the way, old timers insist that you should never use tower bolts and nuts a second time--they may crack from the previous stretching. Use new ones of the proper strength rating. With legged towers built in place, it is a good idea to pour the last footing after the tower is up. Most bolted towers are assembled with a bit of distortion in 'em, and leaving one leg loose lets you cheat a little. Another way to prevent "the last bolts won't go in the @#$% holes" problems is to assemble the whole thing loose and then tighten up. If you do that, be disciplined sure you've tightened every bolt!

Think it out carefully before using a 4x4 truck winch for a tower tilt-down job; the forces are huge even with a gin pole. I once watched a rock-weighted 4x4 3/4 ton Dodge pick-up catapulted to destruction by an 85 foot tower. Lost a nice Jake, too. Also beware underestimating the loads on block-and-tackles used to lower machines from towers. Once had to have a neighbor kid pour perfectly good beer on our gloves to put out the fire.... J Baldwin, Tech Editor, Whole Earth Review, 27 Gate Five Rd, Sausalito, CA 94965 • 415-332-1716.

Solar Cooking

Dear Sirs, I am looking for people in this area who might be willing to help me make a solar cooker. Also any printed materials. Thank-you. Regina Pustan, POB 60724, Palo Alto, CA 94306

Regina, see the 'Things That Work!' in this issue for a review of a solar oven kit. Also Home Power has just published a book, HEAVEN'S FLAME, that gives detailed instructions on how to build a SunStar solar cooker. These ovens are made of cardboard, aluminum foil and glass. They cook as well as the manufactured model that costs thirteen times more (I am including the price of the book with materials cost of SunStar). See ad on pg.91 for ordering information. - Kathleen

Kudos

Your magazine is great, and especially encouraging for do-it-yourself tinkerers like me who prefer to build things rather than buy them (what's the fun of that, anyway?). We have a small system: Two PV panels and one of Bob-O's Lil Otto hydro units which feed some nicads we got from Pacific West Supply (great people!), plus a Power Star inverter. This is actually more than we need, and we intend to keep it that way (we are independent of our independent power system!). I appreciate your ability to make things clear and easy to understand, yet not sacrifice detail or talk down to us non-techies. So, even though we won't be expanding our system, we do want to improve it as new developments arise. That's where HP fits in: We know you'll do the best job of keeping us informed. S W Clarke, Box 74, Swisshome, OR 97480

Light of Day

Dear Home Power Crew, I'm enclosing my renewal form. I've also got one complaint.

HP#20 had an article on efficient lighting ("Lights at Night", pg 15). It reported the Osram EL lamps to be "virtually indistinguishable from daylight". I bought two of them. I was disappointed when I found them yellow compared to my 40 watt twin tube daylight fluorescent lamp (which I find close to daylight). The color quality of the Osrams seemed similar to that of a soft white incandescent.

Nonetheless, I am still renewing (this time for two years). Having a technical background myself, I am very much

impressed by the way your magazine brims with details of your subject matter. It has information that I can't seem to find elsewhere. I understand your desire to broaden the magazine's appeal, but please devote some reasonable fraction of your space to features such as Nerd's Corner, Homebrew stuff, etc. Here's a few suggestions for topics I'd like to see covered.

--Battery Recycling. A good idea would be an article or an interview with a battery recycler/rebuilder (or someone knowledgeable about chemistry). It should cover what can be done and what is being done. It should include lead-acid, alkaline, and Ni-Cad types. AE is a pipedream for me now. Someday I intend to make the switch. Before I do I want to be sure that AE is solving one problem and not simply creating another (please see enclosed newspaper article).

--Inverters. I'm very curious about the new generation of inverters. Could you have an article with details about how they work (including block diagrams/simplified schematics)? Are they feasible for home construction, even though it might be a lengthy, complex project? If so, I would like to see a project in the low to medium power range - 100 to 500 watts.

--Fluorescent Ballasts. Another interesting construction project would be an electronic ballast for fluorescent lights(including details for various sizes/power ratings).

One final question--will a revised edition of 'The Complete Battery Book' be published? Real Goods 1990 Alternative Energy Sourcebook said such a project was due out in Feb. 1990. Now it's no longer listed in their catalogs. I'm enclosing a SASE for a speedy reply on this one. A simple yes or no will suffice (along with a date if yes). You may publish this letter and reply to the other questions in Home Power. Thanks, you're doing a great job! Bill Joy, 515 SE 7th St, Gresham, OR 97080

Hello, Bill. The eyes have it. The Osram EL series has a C.R.I.(color rendition index) of 82, while your Daylight twin tube approaches a C.R.I. of nearly 100. A soft or "warm" white incandescent, on the other hand, only has a C.R.I. of 55. Of course, we're kinda talking apples and oranges, as the compacts are suited for different applications than the long tube fluorescents and vice versa.

Many readers tell us they like the Homebrew articles. We give Homebrew as much space as it needs. The amount depends on how many good projects are sent in by readers. All we ask is that the circuit be prototyped, working, and useful. An article on battery recycling and/or rebuilding would be great! Any battery rebuilders out there like to write?

By now you've already gotten HP23 with Clifford Mossberg's article on How an Inverter Works. There was an article in Radio/Electronics a few years back which gave a schematic and plans for a roll-your-own 50 watt inverter. I built it and it worked, but I can't say I'd recommend them for home use. Inverter technology has come an incredible way. Fully regulated RMS output regardless of input voltage, frequency held to ±.04% (lots better than the grid), load sensing, impulse phase correction, on and on, oh my. I can build an inverter, but I sure as hell ain't gonna plug my VCR into it!

So many folks have asked for an updated Battery Book, that the current plan calls for locking Richard into an unheated monastic cell this winter with only his Mac, espresso pot, and a goodly supply of peanut M&Ms until he produces it. 'Nuff said? Bob-O.

Hi, Bill. My apologies for saying "compact fluorescent light being virtually indistinguishable from daylight". What I should have said was, "these lights have a warm light, not the blue light that makes everyone look corpse-like." I'm working on the revised edition of the Battery Book. I have large quantities of new information to add. I have no firm date for completing the New Battery Book. Bob–O's right, they need to lock me up… Richard

Mac-It-To-'Em

Keep up the good work. I was wondering how many readers would be interested in a Hypercard or Supercard version of Home Power? Mac-It-To-'Em. Recent ice storms in Rochester, NY took out almost all the central electrical facilities (nuclear). The line crews were sure interested in why I still had power. Some areas were out for 2-3 weeks. Even fossil fuels, such as gasoline, couldn't be pumped. One problem everyone in northern climates faces is heat storage. If there is anybody out there who has worked with heat-of-hydration salts for seasonal heat storage, I would be interested in hearing from them. May the Sun light your way, Robert Snell, 60 Lakeview Park Apt A, Rochester, NY 14613

If you include the line art and scans of the photos, Hypercard stacks for just one issue of HP would take 4 Megabytes or so. Unless you've got a "black hole" for a hard drive... If anyone is interested in text files from HP issues, contact Richard. He's been known to fill reader's 3.5 " floppies with all kinds of stuff.

A similar power outage happened in the southwestern Oregon area this winter. First the natural gas went out, then the electric power. We just stuck another log in the stove and watched it on TV. Shouldn't be smug, but it felt good, didn't it? - Bob-O

Serviceable Servel

Dear Home Power Folks, Enclosed is a check for my subscription renewal, my thanks for a job well done on issue #23, and a tip for owners of old Servel gas fridges.

Reflectix insulation is a partial cure for excessive gas consumption. (Cleaning the coils helps too.) Drape a piece of Reflectix over the top of the fridge - leaving the grill in back uncovered, of course. Tape it down to the sides using the silver reflectix tape; nothing else works as well. Yank out the shelves and fit a piece to the back of the inside. This piece should stay in place by friction fit. Cut a piece to fit inside the door with about a 2"-3" gap between it and the door gasket. If you fit this piece tight to the gasket it will interfere with the door closing. You will have to cut out around the latch anyway. The final touch - cut and fit a piece around the sides and bottom of the freezer box. The lowered heat transfer between the freezer compartment and the fridge will allow you to keep your ice cream solid without freezing your pickles. Enjoy your popsicles and propane savings! Yours under the Sun, Hilton Dier III, Middlesex, VT

Thanks for the info, Hilton, I just happen to have an old Servel, Harold, who is getting up there in years. I just reworked the door seal with silicone seal. I did the test where you put a dollar bill across the seal, close the door, and see if you can pull it out or wiggle it. Sure enough, money was slipping out of the seal. It all adds up. See page 67 of this issue for propane info- Kathleen

Gridless Jammin

What's great is that EVERYTHINGS interesting. So much to read. Not like, say, "Time", or "OMNI" or even "Rolling Stone"....Takes 15 minutes to flip through the fluff and learn nothing in the process. Especially enjoy the "How to" articles by homesteaders such as myself - Keep up the good work! How about something on AE Rock 'N' Roll...systems and/or suggestions for musicians who lives and plays off the grid.

But yes: This is a subject of great personal interest - the grand piano that occupies a major portion of my simple shack requires no energy beyond my own to operate, but my musical interests have been expanding to include other keyboards and other musicians. Would like to be able to power a jam session someday. Interested in clues as to what makes and models of synthesizers and keyboards are available or adaptable, or articles by other musicians who for one reason or another found themselves with nothing to plug into...

PS I have an array of 6 Arco - solar "M-701" on a tracker and some VERY old, still functional, telephone co. relay batteries, got 'em used, they're even more used now and someday soon will have to be assisted by a second bank - got a switchboard and an inverter that doesn't work right now.... You get the general picture! Thanks for listening.... Case Cohen, Box 203, Dixon, NM, 87527

There are lots & lots of AE powered musicians out there! Even Richard and I get together infrequently for a solar-powered blues jam. My Peavey Mark VI Bass amp and XR-700 PA work just fine on sunshine! The little inverter buzz would be unacceptable for recording, but for the average jam or even a gig, it would be fine. Most of the synths and keyboards I've seen lately run on DC from a wall cube. Converting these to battery power would be a piece of cake. How about it musicians? Any help with makes and models for Case? Bob-O

Tree Towers

Dear Home Power, I enjoyed Mick Sagrillo's information packed article on Wind Generator Towers in HP#23. I have to disagree, from our experience, with his caveat about using trees for towers. I think trees can make great, inexpensive towers. They fit into the landscape considerably better than steel towers. With the exception of one mishap due to some bad engineering advice, our 100+' Douglas fir tower has worked quite well for us for over five years. It easily supports our Winco 24 volt, 450 watt generator.

Mick mentions four things he has against trees as towers - I'd like to give my view of them. 1) He say that trees are hard to climb safely. Personally I feel considerably safer climbing in trees than in towers. Of course, I've done some moonlighting (not literally!) as a tree trimmer, so I'd rather climb a tree with lots of branches to stand on and hold onto than a bare steel tower. In any case, folks should be tied in with a safety line climbing a tree or tower. We have a permanent safety line in our wind machine tree and I can be up and down it in about 15 minutes.

2) Mick says trees are hard to climb with wind generator parts and tools cluttering up your hands. I agree! But so are towers. This is a foolish way to climb anything. Your hands ought to both be free to climb with. I find that the safest way to deal with the problem is to haul tools and parts up with rope after you are secured at the top of your tower. I do carry some tools and small parts (and my cordless phone) in my many pocketed vest. Then I use a canvas bag and rope to haul up whatever else I need.

3) Mick says trees sway too much. He's right. They must be guyed in order to keep the top still. But I'm inclined to think that they need considerably less guying than some

towers, since they're already built to stand some pretty intense winds. Ours has been through 100 MPH winds and it's still standing. We used 3/8" guy strand anchored to the bases of other trees.

4) I also agree with Mick about dead trees rotting at the ground. It would be silly to use a dead tree for a tower. I'd suggest using a healthy tree and doing everything you can not to wound in mortally. We topped our tree and through-bolted a short steel mast on top. Bolting straight through a tree to attach mast and guys doesn't inflict too much damage. You must avoid putting anything all the way around any part of a tree, since this will girdle it.

I realize using trees for towers is not very conventional (Hey - neither is alternative energy!). But our experience shows that it can work if given proper thought and care. Our tower may not last forever, but so far it's been a lot cheaper and more aesthetically pleasing than erecting a 110' steel monstrosity in our clearing. Ian Woofenden, 378 Guemes Island Rd, Guemes Island, WA 98221

It sounds like that Doug Fir works for you Ian, but you've got to admit that with your tree climbing experience, you're not just the average bear.

I believe that Mick is correct in advising most folks to stay away from trees as wind towers. First, you've got a Douglas Fir to work with. The Doug has very long-fibered, resilient wood. Second, you live in a wet area where a tree has a pretty good shot at surviving topping. Try that with a Pine or even a White Fir in a dry area, and you've got a dead tree in just a few years. Add that to the rest of the rassle with using trees as towers, and you've got a formula for a fiasco. Bob-O

Remote vs Ruined

Dear Richard: Richard Perez in his generally excellent article in Issue #22 of Home Power, "Renewable Energy Offers Freedom", nevertheless draws a couple of caveats from this reader:

1. Regarding the expense of putting in utility lines, which is truly enormous beyond a few hundred feet, the factor we objected to when we built our remote cabin and were faced with the power line choice was the aesthetic cost. Namely, the awful slaughter of trees to establish the corridor and the forever-after cutting or spraying necessary to maintain it. In our rocky area, power lines are seldom buried at utility expense, so every wind storm drops branches or even whole trees on the lines (at least in part because of the newly-opened, wind-tunnel corridor) and the whole system goes out. So negative aesthetics and practical considerations should figure in any decisions on power lines.

2. I think a certain caution should be exercised when telling people to go to pristine, natural places to live because land is cheap and they can enjoy their freedom more in remote lovely areas. This is true BUT, every time man moves in, he displaces other animals and plants that were there first and in our world presently, these other life forms are getting the short end of the stick and need habitat protection. Before some "freedom seeker", armed with all the good and responsible notions of renewable energy charges into some remote and fragile land to establish himself, he should consider the following:

A. One should have an ecologist analyze the site if one isn't sure of what sorts of animals they will be living with or displacing.

B. They should buy as much land as they are capable of to protect remoteness and to keep the area intact. If someone WANTS neighbors nearby, they don't belong in a wilderness, lonely area; they can best have their energy independence in a settled area.

C. These people should consider a legal method of protecting the land, such as a conservation easement, so that the independence and freedom they so much treasure will be possible for some future occupier of the site.

Modern technology is a great privilege and it truly is making OUR remote cabin possible and very pleasant. Our array of PVs and the rest of the gadgetry not only works wonderfully but offers an example to an area (Michigan's Upper Peninsula) that can benefit from energy independence more than most. But the word of caution remains: after all, if everyone were to do as we have done, the remote areas would soon be as screwed up and unlivable as many of the places we leave. Energy independence is one thing; settling down in pristine areas is another. John F Wilson, POB 52, Sturgeon Bay, WI 54235

John, we totally agree with you about the aesthetics of buried power lines. Unfortunately, since it's a "price-less" quality (along with acid rain and other utility-caused environmental disasters) it isn't often taken "into account".

We definitely wish to encourage RE minded folks to disperse from the cities and adopt some dirt. After all, most of the land offered for sale today is hardly pristine. Logged over, grazed over, and generally ripped off of any saleable natural resources is the usual case. Will folks who think in terms of RE do worse than that? We think not.

We believe we all should consider the "stewardship" of any land, water, and air that comes into our keeping a gift

and an honor. "Owning" a piece of the planet is a ridiculous concept. Living lightly and co-existing with all other species is our only hope for survival. Bob-O & the whole HP Crew.

CAFE OLE'

Dear Home Power, I enjoyed reading the articles in issue 22 "From us to YOU". I agree with your view of the president's lack of a serious national energy policy. Apparently so does America. According to a recently conducted poll by The Alliance to Save Energy, 84% of those responding want to increase the CAFE (Corporate America Fuel Efficiency) to 40mpg by the year 2000. That same poll indicates that 82% want tax rebates for buying fuel efficient autos. There is currently several bills in front of both the Senate and House addressing this issue. The most productive bill is the Bryan Bill.

Senator Tim Wirth from Colorado has proposed an energy policy to replace the one the president came up with. While the President's National Energy Policy shows solar and wind on the cover there is little inside to back up the cover. The Wirth bill is more than an attractive cover. It has real plans to reduce our addiction to oil whether foreign or domestic. It would save ten times the energy at a fraction of the cost of the President's plan. The sad fact is most of America is in favor of these plans but have not told their voices in Washington.

I have written all my representatives in Washington and was surprised to receive an answer back from each thanking me for my input. Furthermore, all except Senator Packwood are in favor of these bills.

Home Power readers are action people. If only a fraction of you write your representatives these bills will be passed. Please get involved. Dan Cosgro, 7 NE 79th Ave, Portland, OR 97213-7001

Thanks for the update, Dan. All right, you readers, take action. - Kathleen

Back Issues

Thanks for a great magazine! I have dreamed of living off the grid for over 15 years and see that it's quite possible. Please let me know how I can obtain all the back issues (# 22 is my first). Ever do any stories on disabled AE owners and users? Finally are there any AE stores and/or installers in my area I could correspond with? Thanks, Bob Skinner, 12407 Mopac Exp. N #100, Suite 142, Austin, TX 78758

Well, Bob, the only reason we haven't printed any articles on disabled RE owners/users is because we haven't received any. Sounds like a great subject, though. Most back issues are available. See Home Power's Business page in this issue for info. Here's a list of PV business in your neighborhood:

Advanced Solar Services, 3671 Ridgeway, San Antonio, TX, 78259

Aldac, 2765 Kings Highway Suite 110, Brownsville, TX, 78520

Energy Management Center, Box 12428, Austin, TX, 78711

Osborne Solar, 511 N. Main, Elgin, TX, 78621

San Patricio Solar, Rt. 2 Box 45, Mathis, TX, 78368 • 512-547-2256

South-Tex Industries, Inc., 436 Breesport, San Antonio, TX, 78216 • 800-526-3337 Or 512-341-5073

Sun Trapper Solar Inc., 11953 Starcrest Dr., San Antonio, TX, 78247 • 496-3696

Sunshine Solar Systems, 6213 Grisson Rd, #618, San Antonio, TX, 78238 *- Kathleen*

Battery Life & Death

Dear Home Power Persons: Your no-nukes editorial in issue #22, page 4, made many cogent points, but I presume a lust for concision induced you to gloss over a few related items:

1. If you are worried about disposing of nuclear waste, remember what half-life means. You don't have to wait for all the waste to get completely inert (10,000 years). You only have to wait until the waste is no more active than it was when originally mined (100 years). We humans don't create uranium, we just sort it out into different piles (pun intended).

2. You use the electric car on page 85 as an example of keeping lead out of the environment. Where do you think the quarter-ton of lead from those twenty batteries will be in ten years? The amount of lead on earth has not changed much in the past million years. Metals just get refined and dispersed over and over again. Lead is not a problem unless it is swallowed or inhaled; the real issue is controlling where it goes. Driving 60 mph with a trunk full of lead should not 'ipso facto' qualify persons as environmentalists. Do they recharge from Three Mile Island?

3. If you are boosting the use of Ni-Cads among the solar-minded, what do you think happens to all the cadmium when dead batteries eventually enter the municipal waste stream? According to a full-page article in Scientific American (May 1991, p. 122), nearly 900 tons of cadmium gets incinerated inside busted rechargable shavers and screwdrivers, it turns the resulting ash into highly toxic heavy metal waste, which can't go into regular landfills. Ground water leaching spreads the poison. This is becoming the subject of legislation, which might result in outlawing or licensing the use of Ni-Cads.

4. My belief is that you can't really throw anything away.

You can only move debris from one place on our planet to another. The only proof that humans are intelligent comes from humans themselves, a biased source. Therefore, it may turn out that the best and only way to save our planet is to eliminate humanity, and turn the whole place over to the insects and the grasses. Do we really want to save our planet, or just want to save the human species?

I have been living "off the grid" since Feb., 1987. But I don't like to fall back on a holier-than-thou attitude, imagining that everyone but me is raping the earth. If we efficient ones are to convince others that our way of life is best, we must at least organize our thinking to make our advice valid. Yours truly, Joel Chinkes, Cincinnatti, OH 45244

OK, Joel, let's go for it!

1. I happen to think that 100 years is still too long to keep radioactive waste. One hundred years is five generations of humans and scores more for furry friends and other lifeforms. That's a long time to have to sit on something as hot as nuclear reactor waste.

2. You are in error, I used the EV on page 85 of HP22 as an example of driving smart, not as an example of "keeping lead out of the environment." We all use batteries. Batteries are chemically nasty, otherwise they wouldn't be batteries. Part of the responsibility of being a battery user is proper, safe disposal of the spent cells. When the batteries are spent, recycle the materials. I maintain that the toxic materials within batteries are much more easily contained than say the exhaust fumes from cars.

3. Same as the rap for lead in number 2 above. Sure cadmium is dangerous. One of the safest places for cadmium in an electrochemical cell that is watched over by a responsible user. When the cell eventually dies, recycle its materials.

Battery technologies are changing. The new Ni-H cells from Ovonics contains no cadmium. The ancient and long lived Edison cells use iron instead of cadmium. If we demand more environmentally benign batteries, then we will get them. It's a case of putting our money behind our words. I don't think we will ever have a battery that is totally benign. We will still have to deal with chemically reactive electrolytes.

4. You bet. Nothing disappears, we just rearrange it. As to leaving the planet to the bugs and plants, we may in fact do this. Several million years of evolution have put humans where we are now. A human ego lives for only a short time, but the genes go on. As for our species impacting the planet, you bet we do. We've been changing our world since we started using fire. We need to take care in all we do. I don't know about you, but I'm not giving up on the future. – Richard

Rookie Yearnings

I have been reading Home Power since the first issue, so you know I love you. But somehow I still feel alone with my AE system. In 1987 I purchased two PV panels, hired a friend to wire my house and another to attach the panels. PRESTO! After 13 years, no more kerosene lamps. Over the years since then, I've bought additional items: besides 12VDC lights, a pump, a VCP, a fan. But I have NOT bought a charge controller, inverter, generator, or tracker. Not that I wouldn't like to have a better system. My little voltmeter is inadequate to my needs. Here is the problem: ignorance! What ARE the REAL BASICS of an AE system? I thought I'd just learn along the way, and I have learned a lot, but not enough. I see the need for knowing the stored AmpHours in my system. How awful it is for me to go all winter without that business about charging batteries to "the top" as I do in summer? What about those horrible gases that might kill me if I brought my batteries into the house instead of leaving them on the porch in winter's low temps.? This is basic stuff, I understand. Maybe you could get a couple of knowledgeable types to theorize about FIRST YEAR BASIC SYSTEMS. Of course I'm on an incredible shoestring budget so all costs MUST remain low. I would be very glad to read such ideas in good old HP. Marilynn Walther, Cave Junction, OR

OK, Marilynn, I will write such an article. You can look for it in HP25. Here's answers for some of your specific questions. Completely refilling and equalizing lead-acid cells is essential for long life. This includes the winter. You should be doing an equalizing charge every five or six deep cycles or every two months, which ever comes first. The gases produced by the cells only happen in any amount during charging and equalization. The best place for all non sealed batteries is in a well ventilated area not routinely inhabited by any living thing. If this area is a porch, then the lead-acid cells can get very cold. Low temps cause the lead-acid reaction to become sluggish. Below freezing, lead-acid cells lose about 30% of their capacity. At 0°F., the lead acid cell has lost about 55% of its room temp capacity. Put your batteries in a well insulated, solar heated box.

Your 12 Volt system is simple, effective, and low in cost. If your electrical needs are modest, it will serve you well. If you eventually crave a washing machine, power tools, or as in our case a room full of computers, then your system

will grow in size and complexity. I know of systems that have satisfied for years with a single panel and a battery, no controls, instruments, or inverter. I know of other systems that have 50 panels, and rooms full of batteries and electrical equipment. There's no such thing as a standard system anymore than there is a standard person. Our systems reflect our differences. – Richard

Alone Underground

I have never read your magazine. A friend says it gets into the technology. I have dropped Mother Earth because they got too yuppie. I live very remote in the desert. Have 36 Photovoltaics charging a 48 volt battery bank into 2 Trace inverters. Also tapped ahead of the blocking diode a 110 volt super insulated water heater wired in series on the + side to zap up about 34 volts of the 48, leaving 14 volts left to charge a 12 volt battery bank and heat about 20 gal. of water per day. The 12 volt bank runs a Photocomm Deep Freeze Refrigerator and all my DC lights. I also use 48 volts DC for small amounts of heat into my totally underground house. Stereo, TV, microwave oven, 2 burner hot plate, all kinds of shop tools all run on AC. Also my water Flowlight pump runs on 48 volts DC, raising water 260 ft. into a 1,000 gal. tank next to the well. My water into the underground house is by gravity. My diesel is a 1956 Lister I picked up 15 years ago and ran a lot before Photovaltaics. Now seldom used. I am 1 1/2 miles from the power line. Hope its unsightly poles never get to me. My system is much more reliable than the power line. Inverters or nothing else has ever failed. I love the technology of all this. Every goal I have reached, gave me a brainstorm of another goal. If you have any questions about alternative energy I am willing to try to answer. Donovan A. McDonald, HC61 Box 18 Winslow, AZ 86047

Whew, Don, quite impressive. I would like to see some pictures of your accomplished goals. It sounds great. -Kathleen

BackHome Magazine ad camera ready

Q&A

Being Grounded

Dear Home Power, Enclosed is my renewal for 1991 (the first one, mailed on Jan. 28, seems to have become lost in space or wherever). The magazine keeps looking better and better! I am glad to see that you are branching out into electric vehicles, I think this will generate a lot of interest among "grid folks"; please send me the OOZIE Design Newsletter.

A question for the resident geniuses. A friend of mine has an array of PV panels about 200 ft. from his house, where the battery bank is located. Calculations show that #000 wire is indicated. My friend and I have kicked around a couple of, what we think, are novel ways to reduce the cost of this very long wire run.

a: Use only one run of #000 wire, grounding the other side of the PV array and the matching side of the battery bank and use the earth as one conductor; much as high voltage transmission lines do. Is the voltage (approximately 14 VDC) too low?, is the distributed resistance of the earth too high??, will this work only with high voltage AC, but not with low voltage DC???

b: Use one run of #000 wire pulled through a run of copper pipe buried in the ground; using the wire as one conductor and the copper pipe/conduit as the other conductor, an impromptu coaxial cable! Must the cross sectional area of the pipe/conduit be considered alone or can the current carrying capacity of the earth, with which it is in contact, be considered? What is the current carrying of earth??, is it a constant???, or does it vary with the particular local soil????

Anyway, can some of your resident experts kick this around or just tell us why it won't work. Keep up the good work and try to move toward the mainstream; there is more interest in alternative energy among us "grid folks" than you may think. After all, sooner or later the oil will run out and there will be no more "safe" places to store the nuclear wastes. Sincerely, Edward Read

If the power utilities used the earth as a conductor for their 69Kvac and up transmission lines, anyone living remotely close to a power tower could just stick a couple of copper rods in the ground, run the current thru a rectifier, and charge your batteries-forget the PVs! 'Course, taking a wizz out on the back forty might get a bit dicey... No, one of the 3 conductors on a HV line is the neutral line. The resistivity of earth runs from a couple of KΩs to near infinity depending on soil type, mineral content, moisture level, and a pack of other stuff.

Using copper pipe as a conductor will actually work, assuming all the joints are soldered, BUT the current carrying ability is the same as if you melted the pipe down into a solid wire. I have no idea what that would be for 1/2", 3/4", etc.

Using 400' (round trip) of 3/0 copper wire will carry about 30 Amps @ 14.5VDC with just a hair over 5% acceptable wire loss. Are you tied to a 12V system for some reason? Going to a 24VDC system will allow you to cut down to 1/0 wire for the same # of PVs with only a 4% wire loss. Bob-O

Getting Wired

Our PV site is 200' from the batteries. What size wire should be used? At present we have 4 panels that produce between 7-10 amps. But we wish to expand to 20-30 amps, should we get wire for our future use or can the wire size we use today be incorporated to accept four more panels?

Actually I'm guessing at our present amps but have four Arco panels and wish to go to eight panels. Good magazine. Joey Coccia, POB 18, Dillard, OR 97432

Joey, you don't say whether you are running a 12VDC or higher voltage system. It makes a big difference. If your PV site is 200' from your batts (400' round trip) and you are sizing it for 30 Amps, you will need at least 3/0 copper wire for a 12V system and 1/0 copper for a 24VDC system. For an 8 PV array, (±24A @12VDC or 12A @ 24VDC) you would need at least 2/0 or #1AWG respectively. Bob-O

Three Way Fridge

To answer Richard Cameron, Dillard, OK (p. 88 HP#22) on 3-way refrigerators: By all means increase the insulation. I have just 1" Thermax on the top, sides and freezer door and it uses noticeably less gas. However, they (ammonia absorption refrigerators) are still WAY too inefficient to run on a battery. They operate on heat, so the AC, DC and gas all have the same equivalent efficiency (1 watt= 3.412 BTU). You'd be ahead if you could get direct solar heat into the boiler with some kind of concentrator oven, but it's not very accessible.

Most 3-way models I've seen have the same BTU on gas or 120VAC. The 12 VDC heater is proportioned to only

2/3 of the BTU. This is just to avoid the cost of a 15A DC thermostat - on 12V it just stays on continuously to approximately maintain temperature.

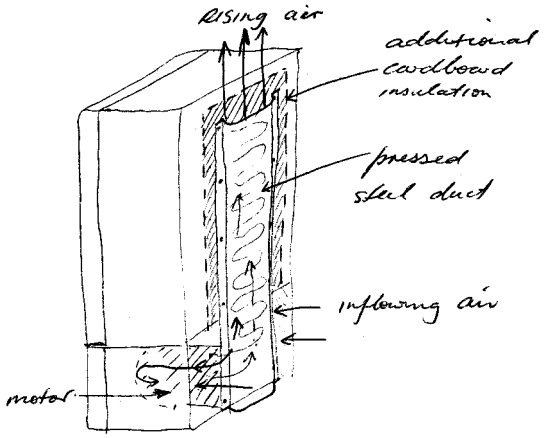
If you have a large enough PV system (20A +), you can use the heater in the refrigerator as a shunt load or diversion load when you have a surplus of power and no more storage capacity. This way your surplus offsets your use of propane fuel. I've had mine that way 7 1/2 years and it uses very little gas in the summer.

Just be SURE the gas valve goes off when the heater is on, otherwise you'll overheat and waste gas. Do not exceed 15 volts on the 12v heater. Also be aware the 12v- operated gas valve (Norcold) consumes 250 ma from the battery just to keep the gas on. Keep cool, S Marshall, RD3 BOX 30-A, Dover-Foxcroft, ME 04426

Cool Fridge

Dear Home Power Crew, Our system in brief: 6 PV panels (2 x Kyocera, 2 x 45w BP, 2 x 58w Solarex) charging 2 x 200 AH battery banks at 24V. A Heliotrope 2324 inverter (sold here as "Solartronics", producing 240 VAC. This powers a small auto washing machine, a wide range of power tools including a 9 1/4" saw (I'm building our home) numerous compact fluoros, bench grinder, W M motor powered air compressor, vacuum cleaner, TV (14" colour Panasonic gave best results of 3 brands tried), video, and kitchen appliances.

I have Danfoss 24V refrigerator components but this is not set up yet. In the meantime I am running an old refrigerator from the inverter as an experiment. This refrigerator has 2 variations from newer types: 1. Thicker insulation 2. A condenser in the form of a pressed steel duct which draws air over the motor, thus avoiding heat from the motor rising up beneath the cabinet. The steel duct also acts as a reservoir of "cool" into which the piped refrigerant can quickly shed its heat. I have further improved efficiency by insulating the duct from the cabinet using heavy cardboard and PV panel packing.



This refrigerator motor is rated at 1.4 - 1.5 amps at 240V and the duty cycle seems to range between 11 and 19%. We place 4 litres of water in a plastic container in the freezer compartment. This turns to ice during the day. We switch the fridge off at night, the ice keeping the cabinet cold while switched off. Used this way, I estimate that refrigeration consumes 20 - 40 amps at 24V per day. In cool sunny weather, the PV panels can nearly keep up with this and the other demands. However, since I started experimenting with this refrigerator, I have made a practice of running the battery charging generator about 1 hour each day in the morning, when the fridge is switched on again, to provide for the initial daily cool down. This practice is essential in cloudy weather.

The battery charging generator is a 1927 vintage (approx) 3 1/2 HP Lister petrol engine (water cooled) V-belt driving off one of the twin 18" flywheels to an ex work boat 24V generator estimated to put out 15 - 20 amp continuous.

This system has several advantages.
1. Cost. An equivalent 240VAC generator powering a 20 amp 24 VDV battery charger would cost well in excess of $1000 whereas this cost less than $500.
2. Easy to live with. 600 RPM is much less stressful than 3600 RPM of modern motors.
3. Water heating. The water cooled motor provides an ideal opportunity to heat domestic hot water at the very time (cloudy weather) when solar heated water is in short supply. Use of this system thus fits in perfectly with prevailing weather conditions, being used most when PV panels are functioning way below their peak, and enables the maximum amount of energy to be extracted from the petrol that is used.

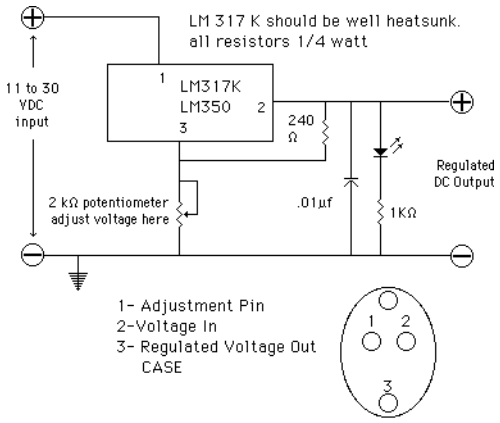
Using only the cylinder head water jacket (no exhaust water jacket yet) we get about 30 litres (7 gallons Imperial) shower temperature plus. Thus; 1 litre petrol = approx 20 amp at 24V plus 30 litres hot water.

I am looking forward to the time when a fully automatic system, similar to the above will be available, sensing low battery voltage, starting automatically, and switching off when the batteries are fully charged.

I have several questions: 1. Is it normal for the voltage regulator of a generator (my reg. is Echlin) to run hot, and if so how hot? On mine, two of the three coils are blackened but the unit still performs okay.
2. Have you any info on using a water cooled heat exchanger for the fridge condenser. It seems to me, this would absorb the rejected heat more quickly and thus, cut

down on motor running time, giving higher efficiency. The slightly heated water could be the first stage of the domestic water supply.
3. Have you a circuit diagram for a DC-DC voltage reducer 24 to 12 or 6 volt. This would be useful for powering certain appliances - radio, tapes, etc.
4. What are the best insulating materials for constructing refrigerator/freezer cabinets? Yours Sincerely, Jonathan Sutton, Bulga Rd., Bobin, Australia 2429

Hello, Jonathan. 1. Your regulator sounds like the electromechanical type. These types often use large power resistors which get very hot. Hot means that you can't hold your finger on the component for more than five seconds. I'd have a spare regulator around if I were you… 2. The concept of using water to remove heat from a refrigerator is sound. Any feedback from anyone who has tried this? 3. Diagram for a DC/DC power supply follows. This circuit uses either the LM 317 (1.5 Amps) or the LM 350 (3 Amps). Very simple and adjustable.



4. The most thermally efficient insulation is now a foam. A closed cell type is best, like PVC. Richard

Ice Farm
Dear Pinhead, Your article in Home Power #21 on Ice Farming got me to thinking. Way back when they didn't have refrigerators (or electricity, for that matter), the common solution to food preservation was the ice house, a year round cooling facility.

I'm not sure about the construction details of these things, but around the turn of the century, in Nebraska, my grandfather (and practically everybody else around those parts) had one. It was apparently rather large (maybe 12-15 ft square) building filled with ice which was in turn packed around with hay or straw (not sure which) for insulation.

Well, I am looking for land up here in the Northwest (a good ice farming country) on which to build an AE homestead. For a variety of reasons, electrical power will be a scarce commodity initially - probably only enough to run some lights. An ice house could be a good temporary solution to the refrigeration problem until the electricity production can be expected to handle refrigeration. Or maybe it could be a permanent solution.

But I don't know of any sources of information on the construction of such things. I don't need general principles - what I need are construction details like, how big? How much ice is needed? How much and what type of insulation? Drainage problems? etc. So I thought I'd write to you in case you had any such information or could point me in the right direction. Perhaps a note in Home Power would turn up a reader with more specific and up to date information? Sincerely, Jim Perry, 3050 - 180th Ave. NE, Redmond, WA 98052

I was able to glean a few more details from my library but this is by no means all the information you want.

The size of the ice blocks taken from the frozen ponds were two ft. square or more, and anywhere from nine inches to a foot thick. It was stored stacked in layers of sawdust. It was pulled up a long chute, by means of ice tongs and a rope, off the sleigh and into the ice house. They chopped a hole in the ice and then used a cross cut saw to saw the cakes out. A team of horses was used to pull the ice from the pond to the sleigh. All the men would work and fill a different farmer's ice house every day till everyone had ice. The ice house walls were about 7-13" thick and were without fire breaks. They were filled with sawdust. The attic was also filled with sawdust, in such a way that it continued to fill the walls as it settled down.

Somewhere I read about an ice house that was built underground. There was some sort of hatch arrangement for opening to lower the ice blocks into it. Regular access was down a wooden ladder. Again, the ice blocks were packed into sawdust for insulation. I would be curious, also, to find out if there is a newer improved method of ice housing in the 90s. C'mon, you HPers, tell us what you know. There has to be someone who knows someone who grew up with an ice house. - Kathleen

Ozonal Notes

OCF

We all had a great time at the Oregon Country Fair. Unfortunately, there just wasn't time (or space!) to do a proper article on the Fair this year. So, here's a thumbnail... In addition to the HP crew, the Fair featured Electron Connection with the PV powered "Solar Fountain", Larry from SunFrost with one of his super-efficient refrigerators, Dave Katz and the Alternative Energy Engineering crew with a pretty amazing PV powered hydrogen generator, voted the "Mr Wizard" award for 1991 by the HP crew, Don Harris of Harris Hydro, Leo Morin of Free Energy Options, Tom Scott's "Copper Cricket", a Real Goods display, and Warren Stokes with the Heart Interface booth. Solar cooking was a happening thing with displays by Joe Radabaugh of Heaven's Flame and the Solar Energy Education Network's mirrored parabola potboiler.

The HP/EC booth ran a line from their PowerStar UPG1300 over to the stage to power up amplifiers from the sun. When word of that got around, the Fair's Energy Park had a sudden influx of unscheduled but excellent electrified performers. Other exhibits ranged from organic farming to masonry heaters to recycling.

And yes, the drums never stop...

Do no harm.
From the native healers in the Australian bush to the neurosurgeons in the world's largest hospitals, it's the first precept of medicine. Ply your trade, do what you can, just don't make things worse. Perhaps the same rule applies to our relationship with the planet. Enjoy your life, use what resources the earth and the sun provide, but use them wisely and don't make things worse. The Earth has a remarkable capacity for regeneration. After all, the planet has been breaking down and recycling the waste products of its inhabitants for millions of years. Given time, it will heal itself from the pollution that we've been causing. Every ounce of particulate not spewed into the air, every pint or pound of fossil-fuel not burned today gives the planet a little more time to catch up. Living lightly, using only what we need and no more, will give us that time.

Do no harm.
It's a concept whose time has come for living on the planet as well.

Bob–O Schultze

Index to Home Power Issues 1 to 23

Two level subject sort, then title, then issue number, and then page number

Please see page 95 for availability of HP back issues. HP1 to HP8 are sold out.

Index for HP1 to HP23

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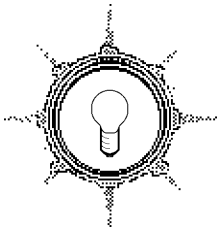
Thomas Lipton - 1870.



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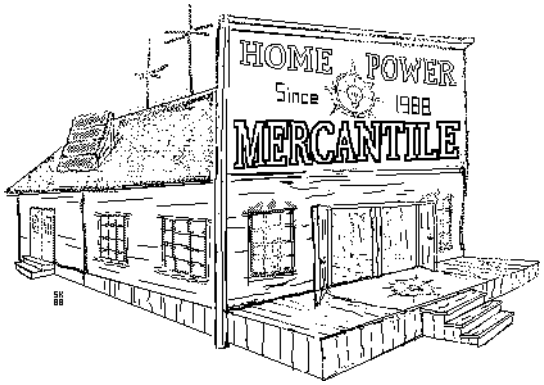

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